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WELCOME

Dr. John K. Burchard
Director, Industrial Environmental Research Laboratories
Environmental Protection Agency
Research Triangle Park, North Carolina

On behalf of the Lab and EPA, I would like to welcome you to the conference on Emissions from Petroleum Refining. It looks like the weather has cleared up and we are going to have a nice day.

Just for your information, I would like to describe a little about the Laboratory. We are responsible for research, development and demonstration for air and water pollution control technology from a variety of stationary sources. We have three divisions: (1) our Utility and Industrial Power Division is concerned with flue gas treatment and particulate technology; (2) our Engineering Assessment and Control Division is concerned with the more near term effects of energy technology such as coal gasification, coal liquefaction and combustion research; and (3) our third division is the Industrial Process Division. We have a sister laboratory in Cincinnati with the same name, and between the two of us, we split up the entire industrial world as far as environmental assessment and pollution control technology. The Chemical Processes Branch of our Industrial Process Division, headed up by Dale Denny, is responsible for textiles, agricultural chemicals which includes pesticides and fertilizers, and last but not least, petrochemicals and petroleum refining. This branch, therefore, is the chief sponsor to this meeting.

As I am sure many of you know, we are currently engaged in a fairly large program to measure emissions from refineries. Refineries are a rather significant part of the fuel conversion industry pollution emissions. These, of course, may be potential health hazards. Results from this program should allow us to aim our Research and Development funds better so that we can determine where our money should be spent as far as control technology development goes. It should help the refiners to reduce hydrocarbon feedstock and product losses, and this, of course, is important from an energy standpoint as well as from an environmental standpoint. And the results should allow the various regulatory agencies to set more realistic standards since we will have a better data base. I would like to make it clear that we in the Laboratory are not part of the regulatory part of EPA, so we are the good guys.

Those of you who are attending the Symposium represent many kinds of industry, not only the oil industry, and various government agencies. Through our combined efforts we can identify and solve our various problems. The program to measure refinery emissions, which I mentioned before, is a good example of this cooperation. When we started in 1976, it was pretty obvious that we would need good cooperation from the petroleum industry to avoid the study just becoming another abstract effort. The staff met with people from the American Petroleum Institute to discuss the scope of work.

API formed a Task Force and together we developed a program which should provide valuable information to both of us. Through the help of the National Petroleum Refiners Association and the API, we have measured emissions in refineries throughout the country. At all the sites we have found real cooperation and valuable assistance. The managerial staff and the people in the refinery have devoted a lot of time and effort. We recognize this contribution and I would like to say that we are really appreciative of it. We couldn't do the study without this kind of cooperation.

We have already sampled at seven different refineries. We have come up with several results; we have defined some major sampling problems and developed some innovative techniques to handle these problems. We have gathered a data base for a variety of refineries and processes. We have identified important sources of fugitive emissions and we have developed some rapid emperical screening methods for leaks which, of course, are one of the major sources of fugitive emissions. We are now just about at the half-way point in the program and this Symposium will give us a chance to share results and get the benefit of your comments which will help us complete the rest of the study. In the next couple days, we will be discussing emissions data, sampling techniques, control methods and potential regulations and control techniques.

Again, I would like to welcome you to our meeting and hope that the next few days prove interesting and productive. Chairman of the first session is Dr. Donald Rosebrook.

HIGH ANXIETY AND THE ENVIRONMENT

Francis N. Dawson, Jr.
President, USA Petrochem Corporation
Santa Monica, California

ABSTRACT

A measure of uncertainty and concern persists among our neighbors about the quality of life to which we may look forward including, especially, air quality. Concurrently, a growing number of individuals are opposing continued growth of our cities and industries for similar reasons. The paper attempts to assess some of the factors which relate to industrial and economic growth, to examine the relation between growth and personal income and to consider briefly the impact of regulatory policy as it relates to our future growth and economic progress.

RESUME

Our keynote speaker is Francis N. Dawson, Jr.,(Fritz) President and Chief Executive Officer of U.S.A. Petrochem Corporation, Inc., Santa Monica, California. He also serves as Executive Vice President of the U.S.A. Petroleum Corporation of which U.S.A. Petrochem is a subsidiary. Dawson first joined U.S.A. Petrochem in February of 1974 as Executive Vice President. Resident of Southern California since 1967, he formerly held the position of Director of Manufacturing with Douglas Oil Company which is a subsidiary of Continental Oil in Paramount, California. He previously served with Continental Oil in various capacities including assignments in engineering technical services and refinery management. He served for several years with Conoco's International Division in New York, Europe and Latin America. He graduated from the University of Michigan in 1955 with a B.S. and a M.S. degree in Chemical Engineering and honors from Tau Beta Phi and Phi Lambda Epsilon. He has served in many professional organizations in the past, including the American Petroleum Institute, Chairman of the Western Oil and Gas Association's Environmental Conservation Committee, and its Refining Committee. He was also a member of WOGA's Pipeline Committee. He is a Director of the National Petroleum Refiner's Association and the California Fertilizer Association. He is a member of the Fertilizer Institute and the Los Angeles Petroleum Club. As the petroleum refining and fertilizer manufacturing arm of the U.S.A. Petroleum, U.S.A. Petrochem produces petroleum products and anhydrous ammonia and operates a 21,000 barrel/day refinery in Ventura California. His paper is being presented by Jim Daily from Chevron.

HIGH ANXIETY AND THE ENVIRONMENT

Let me respond to a letter I received from a woman from Ojai, California, a town which could be considered as an air receptor area from our Ventura plant. Bessie Simon wrote to me about growth and jobs and the quality of life. Here are a few of her comments:

> "Don't you see that you are perpetuating a vicious circle. The more jobs and supplies you produce, the more people. And the more people, the greater demand for more jobs and supplies. And what has been accomplished. Somebody has to take the initiative to stop expansion until the crush of over-breeding dies down. It should have been done long ago. There must be a stop to this blindly expansive, ruthless and irresponsible growth."

Continuing on, she says:

> "What it does to the people doesn't matter, just keep on making liquor, cigarettes, soft drinks, junk foods, silly gadgets, nuclear power plants. Really," she says, "we should start praying that it does collapse before it destroys everything that is good and beautiful. You are demanding the privilege of using our resources in order to supply more of the very things that brought on this sickness." She says: "What are the needs of a sick society? Is it more jobs, is it more material things, is it more luxuries, this philosophy of more is what has gotten us into the mess we are in. Surely then we do not need more of more. We need to about-face, to back-track as fast as possible. The young people should be studying up on farming, old fashioned farming with the help of solar technology and make a go of it as our ancestors did."

She concludes by saying that perhaps we should close our whole plant.

In a nutshell, Bessie Simon is saying:

1. We are responsible for the increased population because we provide more jobs.

2. Perhaps we are abusing our resources.

3. We ought to revert to small farms or small businesses.

4. We are abusing nature and, she adds

5. A liberal infusion of anti-business sentiment.

But the issue she raises is growth. Should we have it and what are its consequences?

As to whether my creation of jobs has the slightest effect on the breeding habits of you in the audience or anyone else, well, let's face it, Bessie Simon, either I'm a lot more influential than you think I am, or your pencil got away from you just a little bit there. Not only am I unable to influence the supply of employees through population control but, as a matter of fact, the people who will be moving into the work force within the next twenty years have already been born. The population growth problem is less serious in the developed nations where the jobs are. It is much worse in poor countries where large families are desired to help with the family support.

More importantly, Bessie Simon is opposed to growth. Is she alone in her objections to growth? Most assuredly not. I will talk mostly about the energy business because that's what I know the most about. But just in our own industry, the anti-growth or the slow-growth advocates have been enormously successful.

Cancellation of the George's Bank lease-sale earlier this year.

Denial of at least thirteen large proposed refinery projects on the U.S. East Coast.

Potential loss of heavy crude oil production in California's central valley.

Dow's difficulty in the San Francisco Bay area.

Lease suspensions for oil shale development.

Delay of Sohio's Long Beach terminal to handle Alaskan north slope crude.

Closer to home, we experienced utter defeat for our company's proposed project in Ventura to reactivate portions of an idle urea facility which had been in use for twenty years, despite a commitment to reduce emissions by 90% from their level under a former owner.

Other problems:

Conoco's Cat Canyon crude.

Exxon's twenty-eight new wells in the Santa Barbara channel.

Crude oil production from Elk Hills.

Phillips $400,000 proposed modernization in Texas.

Yes, Bessie Simon - you have many who agree with you. Why are these projects being challenged or turned down? And these are just the energy related projects. In fact, just a few of them. You are no doubt familiar with other examples in other industries.

Right now, I want to go right to the heart of Bessie Simon's question: Why not forget about this growth, why not go backwards? What good is growth anyway? The role of business is poorly understood by many of our neighbors today.

I'd like to pose a little quiz and, at the same time, recommend to you and your children a little brochure called "The American Economic System and Your Part In It."[1] In the brochure you will find that the gross national product of our country in 1975 was a little over one and a half trillion dollars. Most of you, I am sure, will remember that gross national product is the total of all the goods and services that we produce in the country. Now here's the quiz. What would you guess is the proportion of that one and a half trillion that winds up as personal income? How many of you think that it would be as much as ten percent of the total GNP? Let me have a show of hands. How many of you think it would be over twenty percent? How many think it would be over twenty-five percent? Well, the answer is three-fourths. Seventy-five percent, three fourths of gross national product can be accounted for as personal income. In other words, GNP can be considered in a way as almost synonymous with personal income.

If you divide the GNP, or at least the portion of it that's personal income, by the population, we get something on the order of $15,000 average family income in 1975 spread out among our 214 million people.

One hundred years before that, back in 1876, the gross national product at that time was only 47.4 billion dollars, expressed in 1975 dollars. The population in those days was only 44 million. That means in a hundred years, we increased the population by five times, but the gross national product, and with it our personal income, has gone up 32 times, all expressed again in 1975 dollars. Therefore the real personal income has gone up, and with it our average standard of living, by a factor of roughly six in the last hundred years.

You see what I've done. I've said that personal income accounts for most of our GNP, the production of goods and services. I've divided by our current population to see how much personal income per person we have to date as compared to how much personal income per person we had a hundred years ago.

Well, how did we do it? How did we accomplish this big increase in our average real personal income which is how we get standard of living? First, remember that GNP and personal income are not truly the same. GNP is what we produce. Income simply accounts for most of the cost of what we produce. We were able to increase our GNP and our personal income because we became more productive. Our productivity went up. It went up because we learned how to make better tools, spent the money to buy them, and we drove those tools with energy other than human power. Energy used per person increased 2.5 times from 1900 to 1973. The only time the trend was reversed in the United States was during the Great Depression of the 1930's and, sure enough, both GNP and personal income during that period went down on a per capita basis.

It's interesting to note that the GNP of virtually every major country in the world relates directly and simply to the energy it uses. The United States consumes roughly a third of the world's energy but it produces roughly a third of the world's gross national product.

What are some of the by-products of this growth in personal income? For one thing, we've greatly minimized child labor. The hours that we have to work in a week, our standards of health, education, housing, medical care, and the other amenities, have been achieved only because growth has occurred at a rate faster than the population has grown. In other words, average real income really means standard of living.

Let's take the other approach. Consider what might have occurred since, let's say 1948, if growth had been held down to only the rate of population growth. In 1948, we saw a disposable family income of $7,430.00, that is, in 1975 dollars. Population then went up and employment increased from 58 million up to 84 million in 1973. That's an increase of about 1½ percent a year. If the growth had been restricted during that period to only the same percentage of increase, that is 1½ percent per year, then you and I would still be taking home to our family the same average of $7,430.00 a year of 1975 dollars. Compare that with what really happened -- nearly $15,000.00.[2]

Likewise, taxes that the Government took in in 1948 were only $1,060.00 per family, and that could not have gone up either without growth. Instead, taxes did go up to an average of $3,740.00 per family, some three and a half times. The Government increased Social Security payments 2.7 times and health expenditures 7.8 times. Expenditures for education by the Government increased 4.1 times, and housing went up 7 times. Again, all in 1975 dollars.[2]

Thus, not only has personal income doubled, but Government spending has greatly increased, all adding to the quality of our lives. Had growth been held down to a "slow growth" level of 1½ percent per year from 1948 to 1973, real personal income would be one half of today's level and benefits from the Government services would be about one fourth of what we receive today.

Even more importantly, if "no growth" had occurred, then we could have foreseen the same gross national product divided by the larger population increase or a reduction in real personal income.

Well, enough of the economics lesson, and whether you remember the numbers or not, the important thing is don't let anybody tell you that our standard of living, our personal incomes, and the benefits we get from Government services are not related to growth. They are directly related to growth. They are a consequence of our growth and, more specifically, how much growing we do for the population we have.

Now let's take a look at what can happen to our own local area. Some of you may have seen the Wall Street Journal article on February 8th about Santa Barbara. The article says "hundreds of residents are leaving. Plans for developing the downtown area have been put off for years. Thousands are attracted by the mild climate, scenic beaches, and the relaxed way of life, and that is just the way most south coasters want the place to stay. But preserving the status quo has its social and economic price."

Still quoting from the article, "Construction curbs have sent the prices of existing homes rocketing, driving these homes out of reach for the middle class people with growing families who want more space. People are leaving who want to stay in the area but can't find career opportunities. Limits on business and industrial growth coupled with the inflated housing values have pushed property taxes skyward for those who remain." An auto mechanic wanted to open his own auto repair shop but was forced to leave because slow-growth country is a poor place for that kind of a project. Carpenters have left the area. School enrollment is down. Teachers are losing their jobs. Young people are going away. It's impossible for them to get a decent job and even if they did, they'd have to live at home. Apparently some thoughtful anti-growth proponents recognize an adverse impact but they argue that too much growth would be worse. What alternative do we have? Crime? Poverty? More minorities? Social problems? These are the things we would have to deal with.

My question to you, ladies and gentlemen, is what effect you might foresee by restricting growth to a level below reasonable balance. Remembering that excessive restriction leads to decline in personal income and employment, I question whether the consequences might not be more crime, more poverty, and more social problems than if growth is allowed to occur in an orderly way.

The history of Ventura, our community, has been one of agriculture and petroleum industries. Both are classic examples of endeavors in which productivity gains have been striking. I can still remember when my grandfather first got baling machines and combines and forage harvesters.

The same kinds of things have occurred in the petroleum industry. The industry has been able to grow and increase its output of energy to fuel the tools of industry and transportation.

Bessie Simon would have us go back to the small farm. "Old fashioned farming" to restore the quality of life. Both my grandparents were farmers and I still remember something of the farmer's life in those days. The farmer's standard of living, work load, health and other social values have improved, as has life for most of the rest of us since then.

Should we close our plant as Bessie Simon suggests, or prevent others from growing, or make it impossible for our employees to live here? Are these the answers to growing crime, poverty, minorities and social problems? As Bessie says, Nature and Clean Air have been common denominators of man's existence since the days of pre-history but the progress of his culture, art, music, medicine, leisure, the time to enjoy the out-of-doors, all of this progress has been made possible by our average income and the increased ability of each of us to deliver more goods or services for the time we put in.

The remaining question posed by Bessie Simon is "Are we abusing nature by abusing the use of its raw materials?" Are we wasting precious resources and are we destroying or contaminating others? The answer to both questions is clearly yes.

We have indeed been wasteful and we are now learning to be more conscious but we are not as wasteful as you might think. I said before we use about a third of the world's energy but we also produce about a third of the world's GNP. We can undoubtedly save ten to perhaps twenty percent of our energy usage. There will be a cost as well as an energy consumption to achieve the energy conservation. Beyond twenty percent, I expect impairment of output with concurrent reduction in our personal income and in our related quality of life.

Many of the changes in public attitude toward industry, and the petroleum industry in particular, have come about because of abuses to the environment, our air and our water especially.

These problems led to a rapid proliferation of regulations and legislation: 1) the creation of local APCD's, 2) the Clean Act of 1970, with Federal Air Quality Standards, 3) the Clean Water Act, 4) the California Supreme Court decision in the early 1970's, the Friends of Mammoth decision requiring EIR's on private projects, 5) the Regional Water Quality Water Control Boards. You know this history well.

Obviously there has been recognition of environmental problems. Legitimate restraint on both emissions and growth has occurred as a consequence of these resulting laws and regulations. The abuses are now largely controlled, however.

At least two other important restraints on growth have developed. The first is the rise in the consumer interest groups and the power they exert.

The other restraint stems from the fact that media coverage tends not to favor industrial or business expansion, but rather to flag the opposite view. Hit-and-run journalism clearly leads to impossible public relations and delayed or perhaps defeated projects. Fortunately, we now see some real changes taking place for the better in this area.

Perhaps our case may be typical. Our company has a direct payroll of over $1.5 million a year and we pay some $0.5 million in property taxes. We support some two hundred local businesses, repair shops, suppliers, stationery stores, banks, etc., in the Ventura area. We buy some $3.0 million in goods and services to run the business from people who do business in the Ventura area. Markets permitting and given continuing community support, we see an active future role in Ventura. 1) Our company will not determine population in the next twenty years but we do hope to provide employment for those who will be needing jobs to support their families. 2) Our contribution to society, both local and otherwise, reflects a high level of need -- food and clean fuels -- agriculture and energy. 3) We are a product of the new era in regulatory controls, controls which demand safety to the public and to our employees and which will not tolerate abuse of the environment. If we have difficulty in meeting our limits, it is because no one else has such limits. We cannot exceed ten miles per hour in a fifty-five mile zone for everyone else.

Up to now, I have talked about why reasonable growth is important, some restraints to growth during the past decade, and the contribution companies such as ours can make to their communities. Now what about the future?

Our company may well be among the last major projects we shall see for some time. Recent amendments to the Clean Air Act provide that in any area where air quality standards have not been attained, no new industrial plant can be built after July 1, 1979, unless the State has adopted and the EPA has approved an air pollution control plan that will assure full compliance by the end of 1982, or 1987 in the case of photochemical oxidants.

In an article in the Wall Street Journal on December 28th of last year, John Quarles, former Deputy Administrator of EPA, says this new law, like a loose cannon on a pitching deck, threatens a path of destruction. It is likely to stop construction of new plants or new plant expansions in Southern California, the Great Lakes region, the Gulf Coast, and the East Coast from Virginia to Maine.

EPA adopted and Congress supported a compromise policy of emissions trade-offs or offsets, that is reductions in emissions from other existing sources above and beyond requirements of existing air pollution laws. But then Congress added the additional burden of the total State compliance.

The difficulties with this program are 1) those companies that are planning to build or modify a plant and the workers whom it will employ are without the power to assure completion of the State plan, 2) companies like ours which are already doing ten miles an hour in a fifty-five mile an hour zone have no trade-offs available, and 3) other companies who may have trade-offs now will lose them if the APCD should tighten emission rules, or at the very least, upon completion of their first project.

As it now stands, the new law is rigid, it has no flexibility for non-enforcement. It is mandate for a nearly no-growth policy for over sixty percent of the country's population. The consequences of such a mandate are obvious if you remember the first part of my presentation about growth. There is no doubt in my mind that the results could be disastrous and that a political resolution of the confrontation will have to occur.

Some action will have to be taken, and it will be taken. The political pressures would be intolerable otherwise. Assuming some resolution will occur vis-a-vis the SIP compliance mandate, we may still be tackling the trade-off problems for some time to come. Even if the trade-off policy changes, your work at this conference will have far-reaching impact on companies such as ours who seek new projects upwind from towns like Ojai.

We went through a makeshift "new source review process" before the laws were written using local permitting rules as the authority. The lack of data on emissions, controls and the inability to model those emissions were tough problems for us. At the same time, our opponents had a field day because the claims of environmental impact were more emotionally constructed rather than factually based.

Our experiences with photochemical oxidant suggests that even when you have narrowed the gaps on hydrocarbon emission data, we will still have a lot of work to do before we understand how to use them. The real story will unfold as we use your new data and the new modelling procedures to see if we can control environmental quality while yet allowing a balanced growth to take place in our communities.

In summary, my pitch to you has been this. We have enjoyed a higher standard of living because our personal income has gone up and our hours of work have gone down. Our personal income accounts for 75% of our gross national product and we have been able to increase our personal income only because we have been able to increase our gross national product faster than our population has grown. Continued growth to match population is a must, or we shall indeed go backwards, and backwards in a way that we may not like. Secondly, I have touched on some of the environmental and other problems that have been tackled over the last few years and some of the steps that have been taken to try to correct them. The highly regulated conditions imposed during this last decade are typical of those which our own company must now meet. Finally, I look for ways to minimize potential over-reaction, especially the consequences of the recent amendments to the Clean Air Act concerning review of new sources of emissions. I hope to alert you to the "rock-and-the-hard-place" situation which we as industry now face. While you have a unique opportunity to make direct input to more accurate procedures and data, I urge you also to listen to the issues with a critical and a skeptical mind, to give industry the support it deserves, including greater credibility, and to actively encourage as private citizens in your own communities a policy of balanced growth.

REFERENCES

[1] The Advertising Council, Inc., 825 Third Avenue, New York, N. Y. 10022.

[2] Statistics compiled by Electric Power Research Institute, NPRA Annual Meeting, March 28, 1977.

COMMENTS

Dick Keppler, US EPA, Region I - OCS development on the Georges Bank has not been cancelled, it has been delayed pending revisions of the Environmental Impact Statement. Of the 13 proposals on the East Coast, I have been involved in most of them, and there were only three serious proposals wherein the process design was investigated and presented to us. The remainder were proposals of what would happen if I built a refinery at this point! Of those three serious ones, two are still under consideration, one at East Port, Maine and another one at Hampton Rhodes, Virginia. The third of the three failed because of financial support. I would also like to make a comment that as far as I know, refining is not a labor intensive business and I would expect that the Ventura Refinery running 21,000 bbl/day from 1948 (or whenever it started) to 1978 has reduced manpower, jobs have been eliminated and not increased.

Comment - Mr. Chairman it sounds like there is a difference within the Federal Government as to the cause for the 13 refineries on the East Coast not being developed. The Department of Energy (ERDA or FEA) in a publication did list each of those and contends that it was due to environmental grounds. There is a difference.

Comment - My company is behind the design or did the design of all three of these refineries and I did the environmental design for the refineries. The one that failed financially did get all of the approvals, but did not get the financial backing. The other two have been delayed totally because of environmental reasons.

PETROLEUM REFINERY FUGITIVE EMISSIONS MEASUREMENT EMISSION FACTORS AND PROFILES

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ABSTRACT

As part of an assessment of organic species emissions from stationary sources in the greater Los Angeles area, measurements were made of fugitive organic emissions from refinery valves, pumps, separators and cooling towers. The measurements included emission rate and composition. The technique used for measuring emissions and computing emission factors is presented along with results comparing emission factors to those in EPA document AP-42. Also included are organic species profiles (i.e., percent composition by weight) for fugitive emissions from valves and pumps. Based on this limited testing, it was concluded that the emission factors in AP-42 are reasonable estimates for average emissions and that refinery fugitive emissions are primarily paraffins with low photochemical reactivity.

RESUME

Hal Taback has a Bachelor's degree in Mechanical Engineering from the University of Rochester and a Master's of Science in Aeronautical Engineering from Princeton. He is currently the Manager of Energy and Environmental Systems at KVB where he is responsible for emissions inventories, emission control technology assessment, energy conservation and energy systems reliability. He is currently conducting programs to inventory gaseous NO_x, SO_x, and organic species and particulate matter by size and composition for the California South Coast Air Basin as well as measuring these same emissions from tertiary oil recovery operations. Prior to joining KVB, Mr. Taback was in private practice as an industrial consultant and environmental contractor, and for 16 years he was associated with Aerojet General as a rocket designer and program manager. He is a former Naval engineering officer with four years of active duty. He has also spent three years as a researcher at the Gugenheim Aeronautical Laboratory of Princeton University where he was engaged in the fundamental aspects of solid rocket propellant burning.

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PETROLEUM REFINERY FUGITIVE EMISSIONS MEASUREMENT EMISSION FACTORS AND PROFILES

INTRODUCTION

As part of an assessment of organic species emissions in a region of California known as the South Coast Air Basin (i.e., greater Los Angeles), a test program and an emission inventory was conducted. The program involved the characterization of all organic emissions in the Basin of which oil refineries accounted for a little over 10%. Approximately three weeks of testing with a crew of four was available in the program budget. Therefore, the objectives of the tests were to check selected emission factors published in the EPA document AP-42[1] and to perform GC/MS analyses on emission samples to develop emission profiles (i.e., chemical composition in weight percent). One week was spent in a small (40,000 bbl/day) asphalt refinery and two weeks were spent in a large (180,000 bbl/day) refinery. This paper covers the tests of fugitive emissions from 5,800 valves, 12,000 flanges, 115 pumps, 5 compressors, 3 cooling towers and 3 oil/water separation pools.

VALVES AND FLANGES

Test Method

Fugitive emissions from valves and flanges were measured by spraying the components with soap solution and characterizing the leak rates by the rate of bubble formation (Figure 1). Each component found to be leaking was rated and tagged designating it as a small, medium or large leaker. By measuring the leak rates for a number of small, medium and large leakers, a characteristic leak rate was determined for each of these leak sizes.

The technique for measuring large leak rates was simply to enclose the component in a polybag and let the gas escape from the bag through a meter

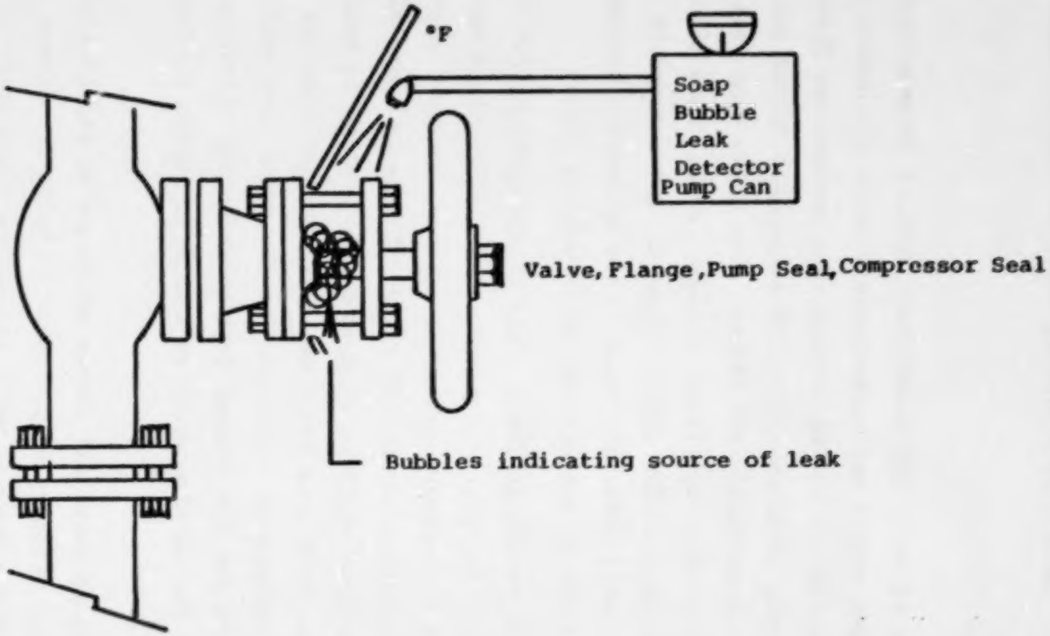
°F
Soap
Bubble
Leak
Detector
Pump Can
Valve, Flange, Pump Seal, Compressor Seal
Bubbles indicating source of leak

Figure 1. Soap bubble detection and temperature evaluation of hydrocarbon fittings.

as shown in Figure 2. For medium and small leaks a dilution method shown in Figure 3 was used. A pump drew a steady stream of filtered air through the polybag and meter. The sample stream was continuously sampled. The test began when the hydrocarbon analyzer indicated a steady state concentration. The leak rate was then determined as the product of the air flow times the hydrocarbon concentration. Samples for GC/MS analysis were taken as shown in Figures 2 and 3. Table 1 is a typical analysis report generated from the GC/MS analysis.

Results

A breakdown of valve and flange test results is presented in Table 2. The number of flanges tested was approximately twice the number of valves since most installations of valves in pipelines involve two flanges. In spraying fittings with soap solution all of the accessible valves and flanges in a process area were inventoried and tested. The valve type breakdown shown was based on the testing at the large refinery while those listed as unclassified were measured at the small refinery. The concept of recording valve type did not begin until after the small refinery tests. Instead, the emphasis was to assess emissions by process unit as presented below.

A surprising result in Table 2 was the proportionately larger number of leaks of all types found in the plug valves. Plug valves were believed to represent "improved technology" over gate valves. However, plug valves require periodic lubrication to prevent leaks. In nearly every case of a leaking plug valve, the leak could be stopped by application of sealing grease. The fact that these leaks were found was an indication that the refineries were in a normal maintenance condition when the tests were conducted. Another probable explanation for the greater leakage from plug valves is that they are used primarily for gas service which is a more difficult application from a leakage standpoint.

A breakdown of valve and flange emissions by pipeline size and fluid content at the large refinery is presented in Table 3. Ethane and propane lines contained gaseous product while all of the other products were liquids.

Table 4 presents a breakdown of the emissions from the small refinery by processing units. For each component at each unit the number of components

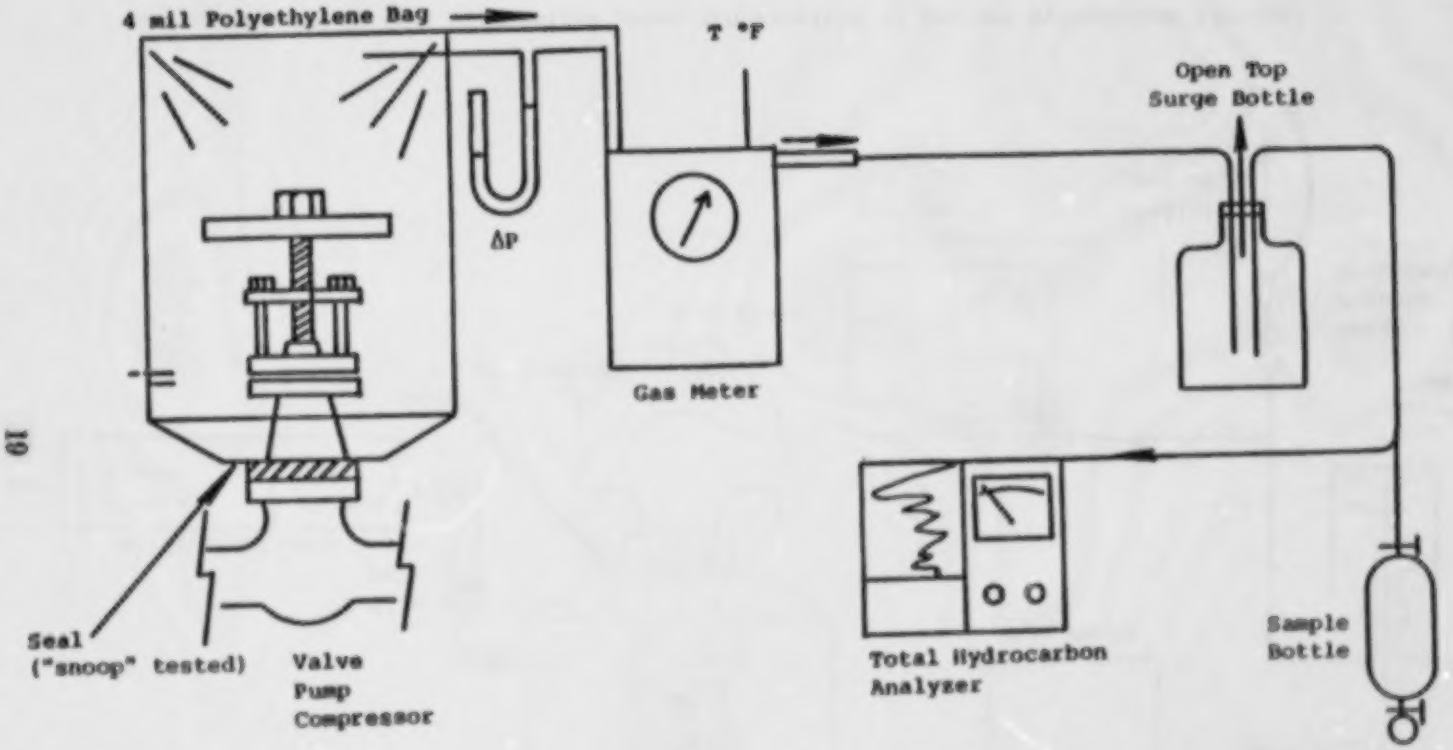
4 mil Polyethylene Bag
ΔP
T °F
Gas Meter
Open Top
Surge Bottle
Total Hydrocarbon
Analyzer
Sample
Bottle
Seal
("snoop" tested)
Valve
Pump
Compressor

Figure 2. Leak rate and concentration measurement of ambient temperature fittings. High leak rates.

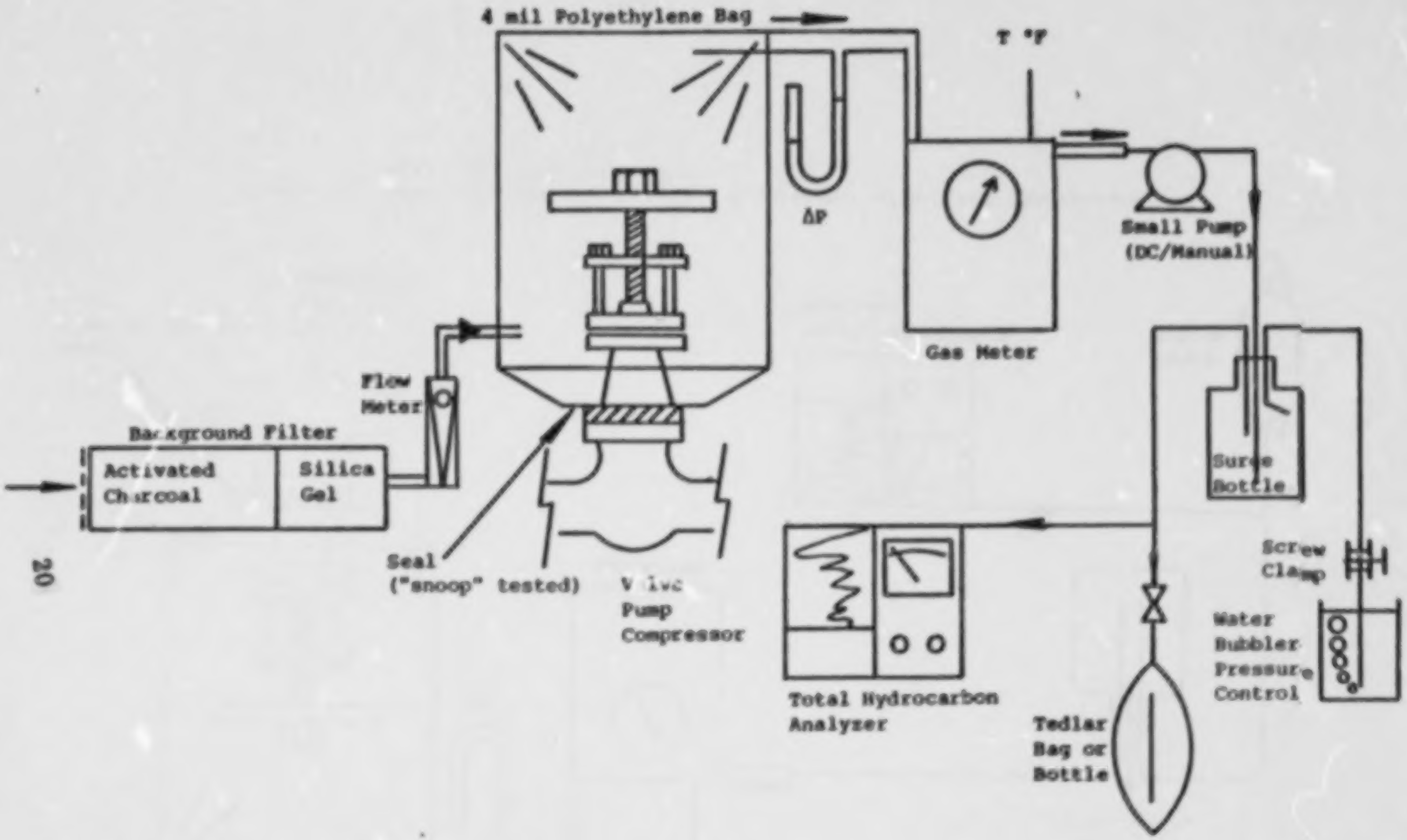
4 mil Polyethylene Bag
ΔP
T °F
Gas Meter
Small Pump
(DC/Manual)
Surge
Bottle
Screw
Clamp
Water
Bubbler
Pressure
Control
Flow
Meter
Background Filter
Activated
Charcoal
Silica
Gel
Seal
("snoop" tested)
Valve
Pump
Compressor
Total Hydrocarbon
Analyzer
Tedlar
Bag or
Bottle

Figure 3. Leak rate by dilution sweep and sampling of ambient hydrocarbon fitting. Low leak rates.

Table 1. TYPICAL GC/MS ANALYSIS REPORT

SAMPLE NUMBER: _ _ _ _ _ BOTTLE 10308 A (DILUTED)*

ARB CODE	EPA NUMBER	CHEMICAL NAME	MOL. WT	UG/L	%WT	PPM	%VOL
1	43201	METHANE	16	34300.	2.3	52200.	5.5
1	43202	ETHANE	30	157000.	10.5	127000.	13.4
3	43203	ETHYLENE	28	81700.	5.5	71000.	7.5
2	43204	PROPANE	44	231000.	15.5	128000.	13.5
3	43205	PROPYLENE	42	968000.	64.8	561000.	59.1
2	43212	N-BUTANE	58	4810.	0.3	2020.	0.2
2	43214	ISO-BUTANE	58	11300.	0.8	4720.	0.5
3	43215	ISO-BUTYLENE	56	7260.	0.5	3160.	0.3
			TOTALS	1490000.	100.	949000.	100.

TOTAL PPM FROM GC AS HEXANE 423000.
TOTAL PPM FROM TOC AS HEXANE 455000.

2 COMPOUNDS OF ARB CLASS I
3 COMPOUNDS OF ARB CLASS II
3 COMPOUNDS OF ARB CLASS III

# DENOTES COMPDS WITH EPA NO. ASSIGNED BY ARLI
( ) DENOTES NO. OF ISOMERS, IF MORE THAN ONE

* RESULTS COMPUTED TO REFLECT THE TRUE CONCENTRATION IN THE ORIGINAL SAMPLE.

Table 2. REFINERY EMISSION SUMMARY, LEAKING VALVES BY VALVE TYPE

Valve Type	Number Tested	Leaks Measured	Leakers Identified		
			Small	Medium	Large
Plug	1300	15	76	21	24
Gate	3100	5	47	6	4
Control	75	2	9	0	3
Unclassified	1300	3	25	35	2
Total	5800	25	157	62	33
Flanges	12000	0	38	20	7

Table 3. REFINERY EMISSION SUMMARY (LARGE REFINERY) VALVE AND FLANGE LEAKS BY SIZE AND FLUID SERVICE

	Valves less than 2 in.	Valves 2 in. and Greater	Fittings & Flanges Less than 2 in.	Fittings & Flanges 2 in. and Greater
Propane	928	596	1180	1583
Small	56	39	13	3
Medium	10	12	0	0
Large	8	16	0	0
Light Gasoline	137	88	146	249
Small	0	0	0	0
Medium	0	0	0	0
Large	0	1	0	0
Gasoline	538	358	551	1007
Small	5	13	1	0
Medium	1	0	0	0
Large	1	0	1	0
Naphtha	56	60	230	176
Small	3	1	0	0
Medium	0	0	0	0
Large	0	0	0	0
Gas Oil	227	352	4	1004
Small	0	1	0	1
Medium	0	0	0	0
Large	0	0	0	0
Fuel Oil	327	220	765	655
Small	4	1	0	0
Medium	2	0	0	0
Large	0	0	0	0
Crude	96	126	367	357
Small	0	4	0	0
Medium	0	1	0	0
Large	0	0	0	0
Residual Oil	62	29	70	80
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Ethane	52	56	73	152
Small	1	4	1	0
Medium	1	0	1	0
Large	0	5	0	0
Freon	37	30	37	75
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0
Sour Water	47	50	—	—
Small	0	0	0	0
Medium	0	0	0	0
Large	0	0	0	0

Table 4. SMALL REFINERY EMISSIONS, VALVE, FLANGE AND PUMP INVENTORY

No. Tested (% of Total)	Reformer Unit	Naphtha Unit	Crude Unit
Valves	500 (100%)	318 (100%)	475 (80%)
Large leaks	0	0	2
Medium leaks	26	0	9
Small leaks	13	5	7
Flanges	852 (70%)	889 (70%)	1,319 (80%)
Large leaks	0	0	0
Medium leaks	13	0	7
Small leaks	7	0	11
Pumps	12 (100%)	7 (100%)	30 (100%)
Large leaks	0	0	1
Medium leaks	1	0	0
Small leaks	1	0	2

tested is indicated along with the percentage of those components that were tested in that unit. For example, on the crude unit 80% of the valves were tested. The 20% of the valves not tested were not readily accessible without special apparatus.

Table 5 summarizes the leak rate measurements and calibration of visual leak rating. The leak rates were measured as described above. The "large," "medium," "small" designations were assigned in the field prior to measuring leak rate. Thus a "large" gas line peak ranged from 7 to 38 lb/day with an average of 18 lb/day.

Table 5. REFINERY EMISSION SUMMARY, VALVE LEAK RATE MEASUREMENTS

Location Code	Fluid	Leak Rate lb/day	Average Leak Rate (calibration of visual leak rating)
Large Leakers			
L	Gas	25	
L	Gas	7	
L	Gas	19	
L	Gas	13	
L	Gas	14	
L	Gas	15	
L	Gas	38	
S	Gas	22	Large Gas Valves 18 lb/day
S	Gas	12	
L	Liquid	18	Large liquid valves 18 lb/day
Medium Leakers			
L	Gas	2	
L	Gas	6	Medium Gas Valves 3 lb/day
L	Gas	2	
L	Liquid	2	
L	Liquid	3	Medium Liquid Valves 3 lb/day
L	Liquid	5	
Small Leakers			
L	Gas	1.0	
L	Gas	0.2	
S	Gas	0.02	
L	Gas	0.02	Small Gas Valves 0.3 lb/day
S	Gas	0.05	
L	Liquid	0.02	
L	Liquid	0.02	
L	Liquid	0.02	Small Liquid Valves 0.02 lb/day
L	Liquid	0.0002	

The computation of emission factors for refinery valves is presented in Table 6. For valves in gas service the leak rate per valve is 0.4 lb/day and for liquid service is 0.003 lb/day. To compare this to AP-42 which makes no distinction between gas and liquid service refer to Table 6. The total emissions for gas and liquid service is 620 + 49 = 669 lb/day divided by the total valves (1700 + 2800 = 4500, 669/4500) equal 0.15 lb/day/valves which is identical to the value given in AP-42.

PUMP SEALS

The pump seals were tested by first sniffing for leaks using a Bacharach TLV total hydrocarbon analyzer then tenting the seal using the measurement technique shown in either Figures 2 or 3.

Refinery pump test results are shown in Tables 7 and 8. While Table 7 indicates that mechanical seals and packed seals have the same proportionate number of leakers (approximately 50%). Table 8 shows that mechanical seals have generally lower leak rates and especially for gas service. Table 6 presents the emission factors. The mechanical and packed seals show nearly the same emission factor for liquid service (< 26 RVP) while for gas service the mechanical seal emission factor was one-sixth that for the packed seal. The leak rate data for the small refinery (Table 8) agree with those for the large refinery amazingly well. During testing the type seals and fluid RVP were not recorded at the small refinery. Later it was established that all their pump seals were mechanical and generally the fluid RVP was below 26 psi. These assumptions were made in developing emission factors.

Based on the above data an overall pump emission factor was calculated (refer to Table 6). Total emissions = 25 + 140 + 5 + 170 = 340 lb/day divided by seal tested (93 + 19 + 12 + 4 = 128), 340/128 = 3 lb/day/seal or 0.5 tons/year/seal. This agrees with the AP-42 value of 3 to 5 lb/day/seal.

Table 6. KVB FUGITIVE EMISSION DATA FOR PETROLEUM REFINING OPERATIONS*

Device Type	Product	Total Inventory No.	No. of Leakers Identified (Average Leak Rate, lb/day·leak)** Large	Medium	Small	Total Emissions (lb/day)	Emission Factor (lb/day·device)
Valves & Fittings							
Valves	Gas	1700	29(18)	23(3)	100(0.3)	620	0.4
Flanges	Gas	3100	0	1(3)	17(0.3)	8	0.003
Valves	Liquid	2800	2(18)	4(3)	32(0.02)	49	0.02
Flanges	Liquid	5700	1(18)	0	2(0.02)	18	0.003
Pump Seals							
Mechanical	< 26 RVP	93	3(7)	4(1)	17(0.01)	25	0.3
Mechanical	> 26 RVP	19	2(70)	0	8(0.06)	140	7
Packed	< 26 RVP	12	1(4)	0	5(0.06)	5	0.4
Packed	> 26 RVP	4	1(170)	0	0	170	40

* Based on test data from Source #7 only.

**See Table 5 for determination of average leak rate.

Table 7. REFINERY EMISSIONS, PUMP SEALS

Seal Type	Reid Vapor Pressure psi	No. Tested	Leakers Identified Small	Leakers Identified Medium	Leakers Identified Large
Mechanical (Large Pafinery)	> 26	19	8	0	2
	< 26	44	14	3	2
Total		63	22	3	4
Packed (Large Refinery)	> 26	4	0	0	1
	< 26	12	5	0	1
Total		16	5	0	2
Unclassified (Small Refinery)		49	3	1	1

Table 8. REFINERY EMISSION SUMMARY, PUMP SEAL LEAK RATE MEASUREMENTS

	Reid Vapor Pressure psi	Seal Type	Measured Leak Rate lb/day	Average Leak Rate, lb/day (Calibrations of Visual Leak Rating)
LARGE REFINERY				
Large Leakers				
	< 26	Mechanical	10	7
	< 26	Mechanical	4	
	< 26	Packed	4	4
	> 26	Mechanical	5	70
	> 26	Mechanical	130	
	> 26	Packed	170	170
Medium Leakers				
	< 26	Mechanical	2	1
	< 26	Mechanical	1	
	< 26	Mechanical	0.002	
Small Leakers				
	< 26	Mechanical	0.05	0.01
	< 26	Mechanical	0.01	
	< 26	Mechanical	0.002	
	< 26	Mechanical	0.002	
	< 26	Mechanical	0.005	
	< 26	Packed	0.2	0.06
	< 26	Packed	0.05	
	< 26	Packed	0.0005	
	< 26	Packed	0.0005	
	> 26	Mechanical	0.07	0.04
	> 26	Mechanical	0.007	
SMALL REFINERY				
Large Leakers				
	< 26	Mechanical	24	7
	< 26	Mechanical	5	
	< 26	Mechanical	2	
	< 26	Mechanical	2	
Medium Leakers				
	< 26	Mechanical	1	1

COMPRESSOR SEALS

Only five refinery compressors were located and tested. One tiny leak of 0.0003 lb/day was located. However, in some related tests conducted in oil production fields an emission factor of 28 lb/day/seal was determined[3].

OIL/WATER SEPARATOR

Open separators were found at both refineries visited. The largest separator found is shown in Figure 4. Samples were taken from pools in each refinery. The sampled oil was taken to the KVB laboratory where the oil was separated from the water and the oil was placed in a dish for evaporation tests at the recorded pool temperatures. The measured evaporation rates were:

Refinery	Evaporation Rate (lb/hr·ft^2)
Large	0.01
Small	0.0002
Small	0.004

The large separator in Figure 4 had a surface area of 14,000 ft^2. At the rate of 0.01 lb/hr·ft^2 the emissions from that separator would be 140 lb/hr. The operators of the refinery estimated that the water flow through the separator was 3000 gal/min. or 180,000 gal/hr. At these rates the emission factor for the separator would be 140/180 or 1 lb/1000 gal waste water. If the KVB measurement was correct, the emission from that separator would be 600 tons/year. The local air pollution control agency rated the emissions from this separator at 1.5 ton/year. Clearly, more work is required in this area.

COOLING TOWERS

Of the three cooling towers tested, valid data were obtained on only one. The unit tested is illustrated in Figure 5. It was a large tower

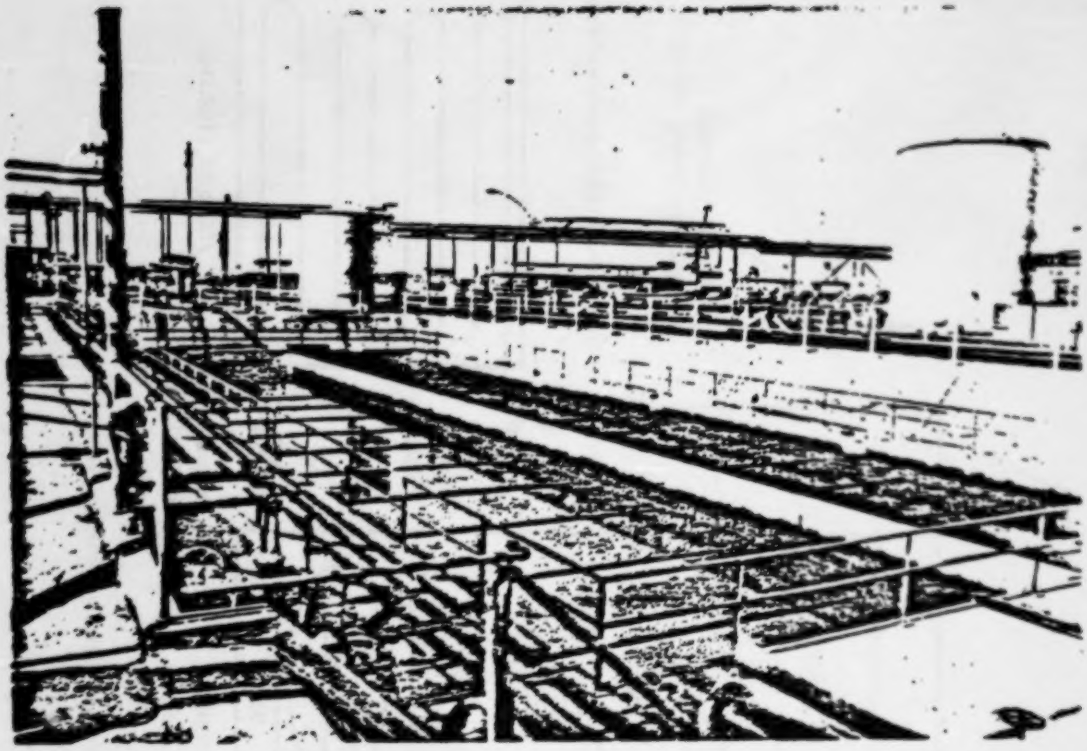

Figure 4. Oil/water separator tested.

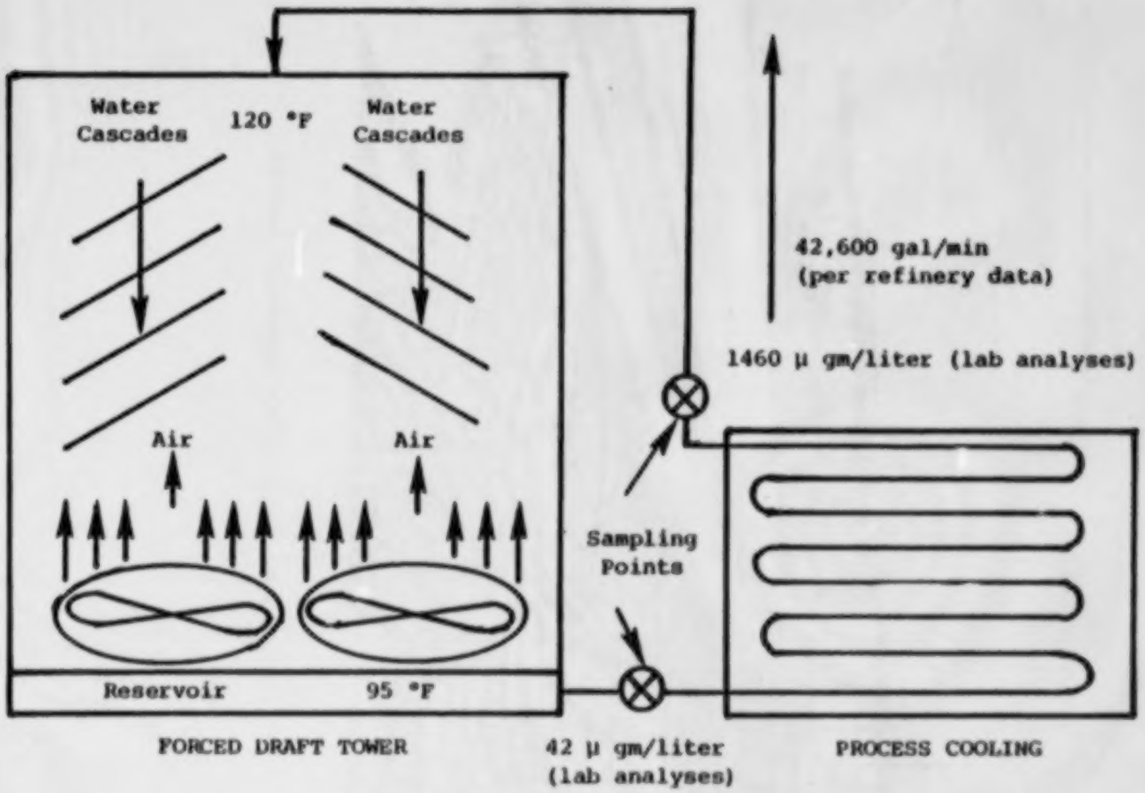
Water
Cascades
120 °F
Water
Cascades
Air
Air
Reservoir
95 °F
FORCED DRAFT TOWER
42,600 gal/min
(per refinery data)
1460 μ gm/liter (lab analyses)
Sampling
Points
42 μ gm/liter
(lab analyses)
PROCESS COOLING

Figure 5. Forced-draft cooling tower schematic.

serving an FCC unit, the gas plant for that FCC and a reformer unit. The water circulation was 42,500 gal/min. Cooling water circulated through the various processes and returned to the tower where the water was evaporatively cooled by forced air circulation.

Water samples were taken at the inlet and outlet of the tower as shown and analyzed (xylene extraction and GC analysis) on organic content. The organic content was identified as 100% isopentane with concentrations indicated on the schematic. The emissions were determined to be the difference in organic concentration times the flow rate as follows:

Change in concentration = 1460 - 42 = 1418 μ gm/liter

$$\text{Emission Rate} = 1418\ \frac{\mu\text{ gm}}{\text{liter}} \times \frac{3.785\text{ liter}}{\text{gal}} \times \frac{\text{gm}}{10^6\ \mu\text{ gm}} \times \frac{\text{lb}}{454\text{ gm}} \times \frac{42{,}600\text{ gal}}{\text{min}} =$$

$$= 0.5\ \frac{\text{lb}}{\text{min}} \times \frac{60\text{ min}}{\text{hr}} = 30\ \frac{\text{lb}}{\text{hr}} \times \frac{24\text{ hr}}{\text{day}} = 700\ \frac{\text{lb}}{\text{day}} \times \frac{365\text{ day}}{\text{yr}} \times \frac{\text{ton}}{2000\text{ lb}} =$$

$$= 130\ \frac{\text{ton}}{\text{yr}}$$

To relate this to AP-42 the emissions must be put into lb/10^6 gal. Other emission factors are in lb/day/1000 GPM

0.5 lb/min x min/42,600 gal x 10^6 = 12 lb/10^6 gal

700 lb/day ÷ 42,600 GPM/1000 = 16 lb/day/10^3 GPM

A comparison of these results with results calculated from published emission factors is shown in Table 9. EPA publication AP-42 lists an emission factor of 6 lb/10^6 gal of cooling water. The API document, referenced on the table, discusses the emissions and indicates that a 1957 study (probably the Los Angeles joint project) specified an emission factor of 3 to 5.3 lb/day/1000 GPM while a "more realistic average figure used by some refineries is 8 to 10 lb/day/1000 GPM." From these emissions factors an emission rate was calculated based on the 43,000 GPM water circulation rate. These emissions are shown in Table 9 compared to the KVB measured emissions from which emission factors were calculated as indicated in the table.

Table 9. COOLING TOWER EMISSIONS AND EMISSION FACTORS
43,000 GPM Water Flow

Data Source	Emission Rates		Emission Factors	
	lb/day	ton/yr	$lb/10^6$ gal	lb/day/1000 GPM
AP-42	400	70	6	
API 931*				
1957 Study	200	40		3 - 5
Best Estimate	400	70		8 - 10
KVB Tests	700	130	12	17

Note: Underlined figures were given and other figures were calculated.

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*API Publication 931, Manual on Disposal of Refinery Wastes, Volume on Atmospheric Emissions, Chap. 7, Pages 7 - 12, Hydrocarbon Emissions, API Refining Dept., Washington, D.C., February 1976.

The higher emission factor determined by the KVB test can be explained by the fact that the hydrocarbon emitted by the cooling tower test was isopentane, a fairly volatile material. Since the AP-42 and API "realistic" estimate agree, KVB feels that there are valid test results to confirm the AP-42 emission factor.

EMISSION PROFILES

In developing the emission profiles for refineries, the following facts and assumptions were used:

1. The typical refinery process schematic is as shown in Figure 6.
2. The primary leaks were from fuel gas lines. (We estimate that approximately 25% of fuel used in the refinery was commercial natural gas and the balance was refinery fuel).
3. Losses from lines carrying heavy liquid were negligible.
4. Approximately 50% of the crude oil processed in a refinery ends up as blended gasoline and 30% becomes other distillate products.

Valves

As discussed above, the leak rate for valves in gaseous products was 0.4 lb/valve-day whereas the comparable leak rate for valves in liquid service was 0.2 lb/valve-day. Estimates of the total valves in gaseous and liquid service in refineries located in the Basin were 25% and 75% respectively. By applying these percentages to the associated leak rates, it was determined that approximately 85% of leaks from valves result from those handling gaseous products.

Using the above information, a "typical" fugitive emission profile for valves was generated. Table 10 gives a summary of the calculation procedure. Listed are the analyzed emission profiles for leaks in various product streams along with the estimated contribution from each to the total. For the purpose of this analysis it was assumed that the percentage of valves in liquid service are as follows:

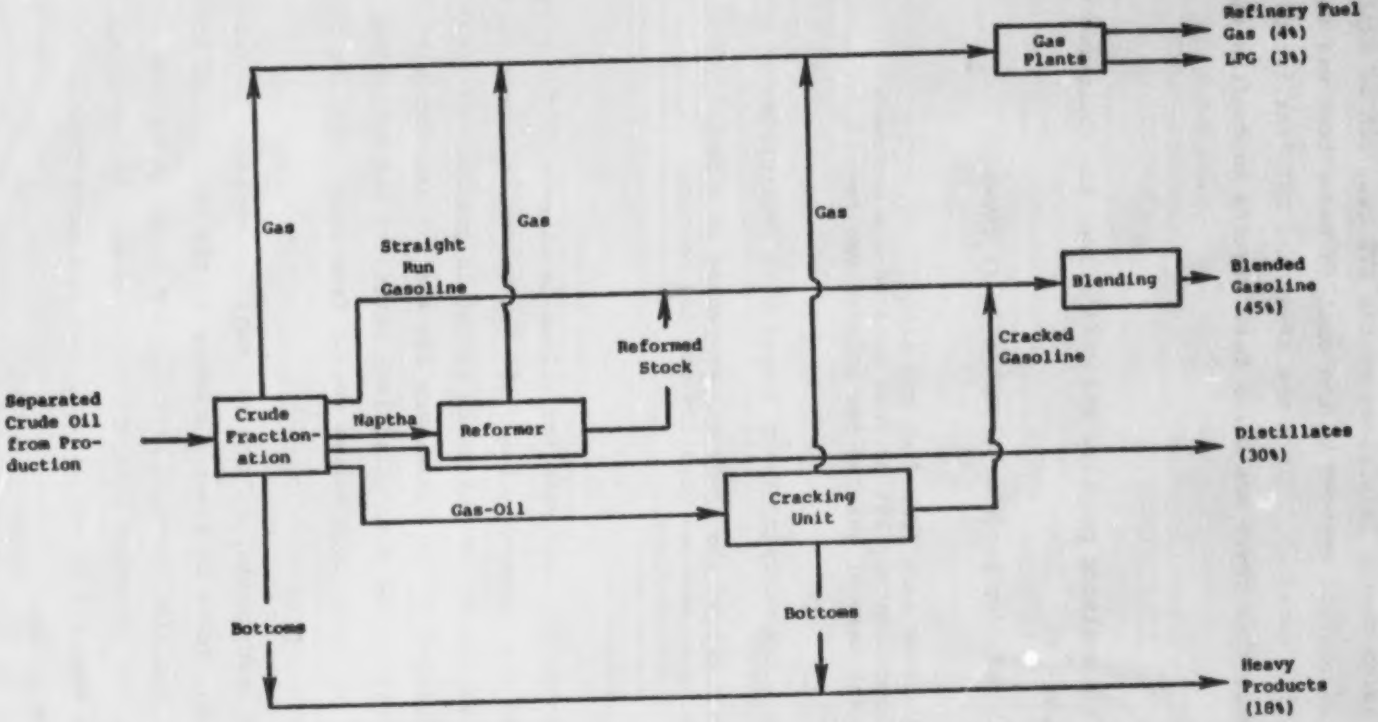
Separated Crude Oil from Production
Crude Fractionation
Gas
Straight Run Gasoline
Naptha
Reformer
Gas
Reformed Stock
Gas-Oil
Bottoms
Cracking Unit
Gas
Bottoms
Cracked Gasoline
Gas Plants
Refinery Fuel Gas (4%)
LPG (3%)
Blending
Blended Gasoline (45%)
Distillates (30%)
Heavy Products (18%)

Figure 6. Refining process schematic.

Table 10. COMPOSITE PROFILE FOR REFINERY FUGITIVE EMISSIONS FROM VALVES

	Refinery Gas	Natural Gas	Straight Run Gasoline	Naphtha	Reformate Stock	Gas-Oil Stock	Cracked Gasoline	Distillate	Composite
Fraction of Emissions	0.64	0.21	0.015	0.015	0.015	0.03	0.03	0.045	
Organic Compounds (wt. percent)									
Methane	16.4	84.5				10.0		4.2	28.6
Ethane	5.1	11.0			0.9	3.8		1.0	5.8
Propane	15.9	3.6	0.2	0.6	13.9	3.3		5.3	11.5
Propylene		0.4							0.1
N-Butane	26.8	0.5	0.7	0.6	24.7	6.5	1.1	12.7	18.3
I-Butane	11.3		0.1					2.5	7.4
Butene							1.1		--
N-Pentane	9.4		1.3	1.3	21.5	7.4	19.7	11.0	7.7
I-Pentane	10.7			0.4		3.8	21.4	5.0	7.8
N-Hexane	2.8		3.2	6.2	19.3	11.8	15.4	9.0	3.4
I-Hexane	1.3		1.1	6.6		6.0	12.8	3.3	1.6
N-Heptane	0.1		1.4	1.8	10.0	8.3	14.9	8.6	1.4
I-Heptane	0.2		3.4			16.0		2.0	0.8
N-Octane			50.1	6.4	9.7	7.9		9.9	1.8
I-Octane			4.7	5.6			4.1	3.0	0.4
N-Nonane			2.8	8.3		4.4		6.5	0.6
I-Nonane			8.5	20.6			0.2	0.5	0.5
N-Decane						3.5		14.8(1)	0.8
I-Decane			2.6	16.6					0.3
C-7 Cycloparaffins			1.0	2.4			3.9		0.2
C-8 Cycloparaffins			0.2	0.6					--
C-9 Cycloparaffins			2.6	4.8			0.3		0.1
Toluene			3.2	6.2		7.3	3.0		0.5
Xylene			2.6	7.0			1.6		0.2
Benzene			1.4	2.5			0.5		0.1
Cyclohexane			0.9	1.5				1.0	0.1
	100	100	100	100	100	100	100	100	100

(1) C_{10}'

Straight Run Gasoline	10%
Naphtha	10%
Reformate Stock	10%
Gas-Oil Stock	20%
Cracked Gasoline	20%
Distillate	25%

For this analysis, the distribution was not critical since the leaks from valves in liquid service constitute only 15% of the total emissions.

Because 85% of the emissions are from valves in gas service, the composition of the natural gas and refinery fuel gas had a very significant influence on the composite emission profile. A much more detailed analysis would have also incorporated leaks from other gaseous lines within the refinery; however, data on these internal gaseous stock transfer were not available.

Pumps

Tests were also conducted on 80 pumps to characterize emission rates from these fugitive sources. For the purposes of this analysis it has been assumed that leaks from pumps occur only from the liquid product lines as previously described. A summary of the calculation procedure is given in Table 11. As with valves, a much more complex analysis was possible; however, existing data are only sufficient to make a cursory estimate.

CONCLUSIONS

The conclusions reached as the result of these tests were:

1. The emission factors for valves, flanges and pumps in AP-42 are reasonable.
2. In valves and flanges the large leakers (averaging 18 lb/day/valve) accounted for over 80% of the fugitive emissions. Medium leaks (averaging 3 lbs/day/valve) accounted for over 10%. Together they accounted for approximately 95%.
3. Refinery fugitive emissions are primarily paraffins with low photochemical reactivity.

Table 11. COMPOSITE PROFILE FOR REFINERY FUGITIVE EMISSIONS FROM PUMPS

	Straight Run Gasoline	Naphtha	Reformate Stock	Gas-Oil Stock	Cracked Gasoline	Distillate	Composite
Fraction of Emissions	0.10	0.10	0.10	0.20	0.20	0.30	
Organic Compounds (wt. percent)							
Methane				10.0		4.2	3.3
Ethane			0.9	3.8		1.0	1.2
Propane	0.2	0.6	13.9	3.3		5.3	3.7
N-Butane	0.7	0.6	24.7	6.5	1.1	12.7	7.9
I-Butane	0.1					2.5	0.8
Butene					1.1		0.2
N-Pentane	1.3	1.3	21.5	7.4	19.7	11.0	11.1
I-Pentane		0.4		3.8	21.4	5.0	6.6
N-Hexane	3.2	6.2	19.3	11.8	15.4	9.0	11.0
I-Hexane	1.1	6.6		6.0	12.8	3.0	5.5
N-Heptane	1.4	1.8	10.0	8.3	14.9	8.6	8.5
I-Heptane	3.4			16.0		2.0	4.1
N-Octane	58.1	6.4	9.7	7.9		9.9	12.0
I-Octane	4.7	5.6			4.1	3.0	2.8
N-Nonane	2.8	8.3		4.4		6.5	3.9
I-Nonane	8.5	20.6			0.2	0.5	3.1
N-Decane				3.5		14.8(1)	5.1
I-Decane	2.6	16.6					1.9
C-7 Cycloparaffins	1.0	2.4			3.9		1.1
C-8 Cycloparaffins	0.2	0.6					0.1
C-9 Cycloparaffins	2.6	4.8			0.3		0.8
Toluene	3.2	6.2		7.3	3.0		3.0
Xylene	2.6	7.0			1.6		1.3
Benzene	1.4	2.5			0.5		0.5
Cyclohexane	0.9	1.5				1.0	0.5
	100	100	100	100	100	100	100

(1) C_{10}^{+}

4. More work is required to develop experimental techniques for increasing evaporative emissions from oil/water separators, cooling towers, etc. and to derive emission factors from these sources.

ACKNOWLEDGEMENTS

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FUGITIVE HYDROCARBON EMISSIONS - MEASUREMENT AND DATA ANALYSIS METHODS

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ABSTRACT

A statistical data analysis method for determining fugitive source emission factors from field leak rate measurements is presented, along with a discussion of general measurement techniques. Data on valve emissions obtained in a measurement program conducted at an Exxon chemical plant are highlighted, both as an example of the data analysis method, as well as in the discussion of the results of this study. A comparison is made among valve emission factors from product line areas receiving varying degrees of maintenance. This comparison shows the potential for emission reduction through improved maintenance at a given facility, although further studies would be needed to accurately quantify the expected reduction for the general case.

RESUME

Karen has a Master's Degree in Chemical Engineering which she received from the University of Michigan and she is now employed by Exxon Research and Engineering. She has been there since 1974 working in the general areas of measurement and control of hydrocarbon emissions from both marine vessels and inplant sources. Currently she is head of the Hydrocarbon Emissions Control Group within the Environmental Control and Safety Division of Exxon Research and Engineering.

Karen M. Hanzevack

FUGITIVE HYDROCARBON EMISSIONS - MEASUREMENT AND DATA ANALYSIS METHODS

Information on hydrocarbon emissions from fugitive sources has recently been obtained at an Exxon chemical plant. A measurement program was conducted which included monitoring emissions from fugitive sources, including valves, pumps, compressors, and safety valves. Although the specific purpose of the study was to provide accurate fugitive emissions estimates for the particular plant under study, the measurement techniques and data analysis procedures developed as part of the program are of general interest in evaluating or preparing for other current or future test programs in this area.

The test program which was conducted can be broken down into three phases: screening, sampling, and data analysis. The screening phase included determining the total number of components of each source in the plant, as well as developing a sampling plan. The sampling involved "bagging" specific sources identified in the screening phase, and developing hydrocarbon leak rate data for each source. Finally, a statistical data analysis method was identified which was judged to result in the best estimates of emission factors for leaking components for each source type. These values, combined with data on the percentage of components which leak and the total number of components in the plant, can be used to estimate total fugitive emissions.

The screening and sampling phases of this program will be briefly outlined. The main emphasis in this presentation will be on the methods used for analysis of the data developed in this study. Specifically, the work done on valves will be highlighted, both as an example of the data analysis methods and in the discussion of the results of this study.

SCREENING AND SAMPLING PLAN DEVELOPMENT

The first objective of the screening phase was to determine the total numbers of plant-wide components for each source type. These values were tabulated from chemical plant flow sheets for each of the three product line areas within the plant. The total number of valves was over 20,000, while the number of other components ranged from approximately 200 to 600.

Based on these numbers, it was decided that random sampling of approximately 10% of the pumps, compressors, and safety valves could be expected to result in representative samples without requiring an unreasonably large measurement effort. The components to be sampled were randomly selected from the various process units throughout each of the three product line areas in the plant. The data obtained in sampling these components were used both to determine the percentage of each source which leaked and to determine the actual leak rates of the leaking components.

However, due to the extremely large number of valves in the plant, a more detailed sampling program was developed to set the number of samples at a reasonable level, while still providing a data base which would be an adequate representation of the entire plant valve population. The approach taken was to categorize the valves by service (liquid or vapor), size ($\leq$ 4 inches <), and line pressure ($\leq$ 50 psi <) such that eight classes of valves were established.

Approximately 10% of the valves in each product line were screened with soap solution to detect leaking components. Specific valves were selected for screening, such that each class of valves was screened in approximately the same proportion as it occurred in the general population. All valves found to be leaking were counted and tagged. The advantage of this sampling approach is that it is likely to give a more accurate representation of the total population with fewer samples than by using simply a random sampling procedure. Using this approach, approximately 1% of the total valve population, about 200 valves, were randomly sampled from the set of valves found to be leaking.

The information obtained during the valve screening provided an estimate of the percent of the total population of valves which leak. Therefore, only leaking valves needed to be sampled and analyzed.

FIELD SAMPLING METHODS

A "bagging" technique was used to measure the leak rates of those valves which were selected during the screening phase of the study. The "bagging" technique generally consists of enclosing the emission source in a mylar-type sheeting. Figure 1 shows the sampling equipment used. Plant instrument air was directed into the mylar enclosure to serve as a carrier stream for the leaking hydrocarbon vapor. The air was first passed through a dessicant and charcoal filter, to remove any water vapor and hydrocarbon present. The flowrate was measured by a calibrated rotameter and held constant during the sampling. The flowrate was set to maintain a slight positive pressure in the enclosure. Both temperature and pressure were monitored. The air/hydrocarbon stream was sampled from an outlet connection in the enclosure on the opposite side from the air inlet. The dry gas meter was used to determine that vapor was flowing through the line into the sample and to verify that a stable rate out of the enclosure had been obtained prior to collecting the sample.

This method does not require air samples to be taken along with each source sample, once the efficiency of the air filter has been established. Therefore, this method minimizes the number of sample analyses required, as compared to a method using ambient air as the carrier stream. Also, this method is not particularly sensitive to leaks out of the enclosure, since the actual amount of air diluting the hydrocarbon vapor is measured upstream of any possible enclosure leaks.

The hydrocarbon/air samples were analyzed by gas chromatography techniques, giving total hydrocarbon concentrations, as well as a breakdown by hydrocarbon component. From these data, total hydrocarbon molecular weights were determined for each sample, in order to accurately determine mass leak rates. The temperature readings were used to accurately determine flowrate. Replicate samples were generally taken and their results averaged to get a leak rate for each component sampled. A computer program was developed to carry out these calculations, resulting in a leak rate, in pounds of hydrocarbon per hour, for each component sampled.

This measurement method and calculation procedure yielded a set of hydrocarbon leak rate data for each source. A method for statistically analyzing these data was then defined, which would allow the leak rate data from the set of components sampled to be generalized to a representative emission factor, with confidence limits, for the entire plant-wide population of leaking components of a given source type.

DATA ANALYSIS

General Data Analysis Technique

By virtue of the methods used for sample selection, it was concluded that the samples taken were in fact random samples; that is, every component had an equal chance of being sampled. Therefore, the samples can be assumed to be representative of the entire population of components in the plant. This assumption is a necessary condition for the statistical analysis used to develop estimates of the average emission rates for the entire population of leaking components based on the leak rates of the components which were sampled.

The first step in the data analysis is to determine the frequency distribution of the data for each of the four general source types sampled. This is done by finding the maximum and minimum leak rate values and dividing this range into a convenient number of equal cells. The number of data points which fall into each cell is then plotted against the mid-point value of each cell to obtain a frequency distribution of the data set. Such a frequency distribution is shown in Figure 2, using the valve data as an example.

This frequency distribution provides information about the general characteristics of the data set. It can be seen from Figure 2 that most of the valves measured have small leak rates and that very few valves account for the high measured rates. A similar distribution was obtained for each of the other source types sampled. These data clearly do not lie in a common bell-shaped curve which is characteristic of what is known as a normal frequency distribution.

Only a relatively small amount of development work has been carried out on statistical analysis of sampling data from non-normal distributions. The widely accepted approach to analyzing data from such a distribution is to seek a transformation of the data set which will result in a new data set which is normally distributed. This is done because there is a large body of well-proven and widely accepted theory related to the analysis of normal distributions. This theory allows for statistics developed from a sample to be projected to the parent population. An inverse transformation is then carried out to convert the statistics developed for the transformed (i.e., normal) distribution back to the form of the original data.

A common transformation to consider in cases such as this one, where the data are significantly skewed, is to take the natural logarithm of each data point. A new data set is then obtained made up of the logarithms of the original data set. Figure 3 shows the frequency distribution for the data set of logarithms of the original valve data. By observation it can be seen that this transformed data set is approximately a normal distribution. Tests for normality exist, and therefore the validity of the transformation can be checked, and, if need be, correction factors can be applied to account for deviations from normality.

Standard statistical tests for normality were made, which included calculating the skewness, or relative spread, and the kurtosis, or relative height, of the distribution. From these tests it was determined that the log transformation had resulted in a distribution which could be assumed to be normal for the purpose of statistical analysis. This was the case not only for the valve data, but for all source types sampled. No corrections to account for deviations from normality were necessary. Therefore, the validity of this analysis technique was verified for these sets of fugitive emissions data.

By working with the data sets obtained by taking the natural logarithm of the original data for each source type, the population mean values and confidence limits can be determined. This method is judged to yield a better estimate of the population mean than that obtained by simply taking the arithmetic average of the original data. This is the case because, by working with a normal distribution, more information about the data can be incorporated into the calculation of the population mean value.

Calculation of Results

Calculations made were based on the general statistical data analysis techniques discussed above. The computer program was extended to perform the statistical analysis on the set of leak rate values calculated from the field data. Table 1 shows the steps in the statistical treatment of the data. Natural logarithms of the data sets were taken. Using these values, the mean, standard deviation, skewness, and kurtosis were calculated for each source type. The skewness and kurtosis values provided a check on the assumption of a normal distribution. The mean and standard deviation obtained for the data set of logarithms were then transformed back into the form of the original data set. This transformed mean value is the best estimator for the population mean value. It is this number which is the emission factor for leaking components.

Confidence limits for the population mean were calculated at the 3σ, or 99.75% confidence level. This means that for repeated random samples of the same size, the calculated mean values of the samples would lie within the given confidence limits 99.75% of the time. The 3σ level represents a higher degree of conservatism than the 2σ (95%) confidence level normally used in engineering applications. This higher degree of conservatism was judged to be appropriate for this study mainly because of the extremely skewed leak rate distributions and the general lack of experience with this type of data.

Discussion of Results

The valve results are summarized in Table 2. The leaking source emission factors shown in this table represent the best estimates of leaking valve emissions within the stated confidence limits at the specific chemical plant involved in this study. In combining the valve data from each product line, a factor of 0.031 lb/hr per valve, with a range of 0.017 to 0.057 lb/hr, was obtained. Furthermore, 15% of the total population of valves were found to leak. Therefore, the plant-wide valve emission factor is 0.0047 lb/hr. This is equivalent to 0.11 lb/day per valve, which can be compared to the valve emission factor from AP-42 of 0.15 lb/day per valve.

The valve data were also analyzed separately by product line, in order to observe any systematic differences which might be present. As shown in Table 2, the product line results show significant variability. A preliminary analysis of the data suggests that the level of maintenance in each product line is the main variable that could account for these observed differences. Being at the same facility, factors such as ambient conditions and plant age are not significant variables. Also, the screening data showed that the valve categories of service, line pressure, and size are represented in approximately the same proportion in each product line area, although the products being handled do vary.

Maintenance programs are often defined within a given product line area and, therefore, significantly different levels of maintenance can occur from one area to another. It has been determined that the three product line areas at this facility have three different levels of maintenance. One area performs what can be referred to as routine maintenance for this facility, another has a somewhat improved maintenance program in effect, while the third area has been conducting a special maintenance program to minimize the loss of high-valued products. The differences in valve emission factors for each area are significant. The emission factor for the area with the best maintenance practices is approximately one tenth of the factor from the area where routine maintenance is performed. The area with an intermediate level of maintenance shows a reduction about half as great.

Not surprisingly, these results suggest that fugitive emission factors are a direct function of maintenance. However, it is important to emphasize that the quantitative results discussed above only apply specifically to the facility under study. Additional studies at other facilities would clearly be needed to determine the relative impact of maintenance on emissions, as compared to other influencing elements which could vary from one facility to another. Without additional studies, the generalization of these results to other chemical plants or refineries would be inappropriate.

CONCLUSIONS

The results of this study suggest that there are two main areas beyond actual leak rate measurement methods which need to be thoroughly addressed in any current or future fugitive emissions studies. Data analysis techniques should be used which provide the best estimate of total population emission factors for a given source type. Secondly, information on maintenance procedures should be developed along with other correlating parameters in order to address the question of the effect of maintenance on fugitive emission factors.

The data analysis technique identified in this study as providing the best estimate of total population emission factors is based on transforming the leak rate data into a normal frequency distribution. A transformation found to be valid for the data obtained in this study is a logarithmic transformation. Such a method is recommended over the use of a direct arithmetic average calculation because it provides a more representative factor by making use of more of the information obtainable from the data. Also, it allows for a straightforward calculation of the confidence levels associated with the emission factors. Furthermore, it is important that a standard analysis method be adopted, to avoid the generation and use of different factors based on the same data set.

Developing information on the levels of maintenance associated with the specific fugitive emissions data should be included in fugitive emission measurement programs. Maintenance levels should be defined so as to permit emission levels to be correlated to maintenance, as well as to other influencing parameters. This is important not only in defining emissions, but in the consideration of reasonable means to reduce these emissions.

Table 1 STATISTICAL TREATMENT OF DATA

Transformation of Data:

x = component leak rate

$y = \ln(x)$

Statistics of Transformed Data Set:

$\bar{X}_y$ = Arithmetic mean of y values

σy = standard deviation of y values

Statistics for Original Data Set:

$X = \exp(\bar{X}_y + 1/2 \; \sigma y^2)$ = population mean

$\sigma = \sigma y / \sqrt{n}$ = standard deviation of the mean,

where n = sample size

3σ confidence limits $= \exp[(\bar{X}_y \pm 3\sigma) + 1/2 \; \sigma y^2]$

Table 2 SUMMARY OF VALVE EMISSION FACTORS

Source (Sample Size)	Leaking Source Emission Factor (lb/hr/valve)		Percentage of Leaking Components	Plant Product Line Emission Factor (lb/hr/valve)
	Mean Value	3σ Confidence Limits		
Total Plant Valves (197)	0.031	0.017-0.057	15	0.0047
Product Lines:				
A-Routine Maintenance (100)	0.032	0.014-0.076	17	0.0054
B-Improved Maintenance (49)	0.019	0.008-0.047	16	0.0030
C-Special Maintenance Program (48)	0.008	0.002-0.026	8	0.0006

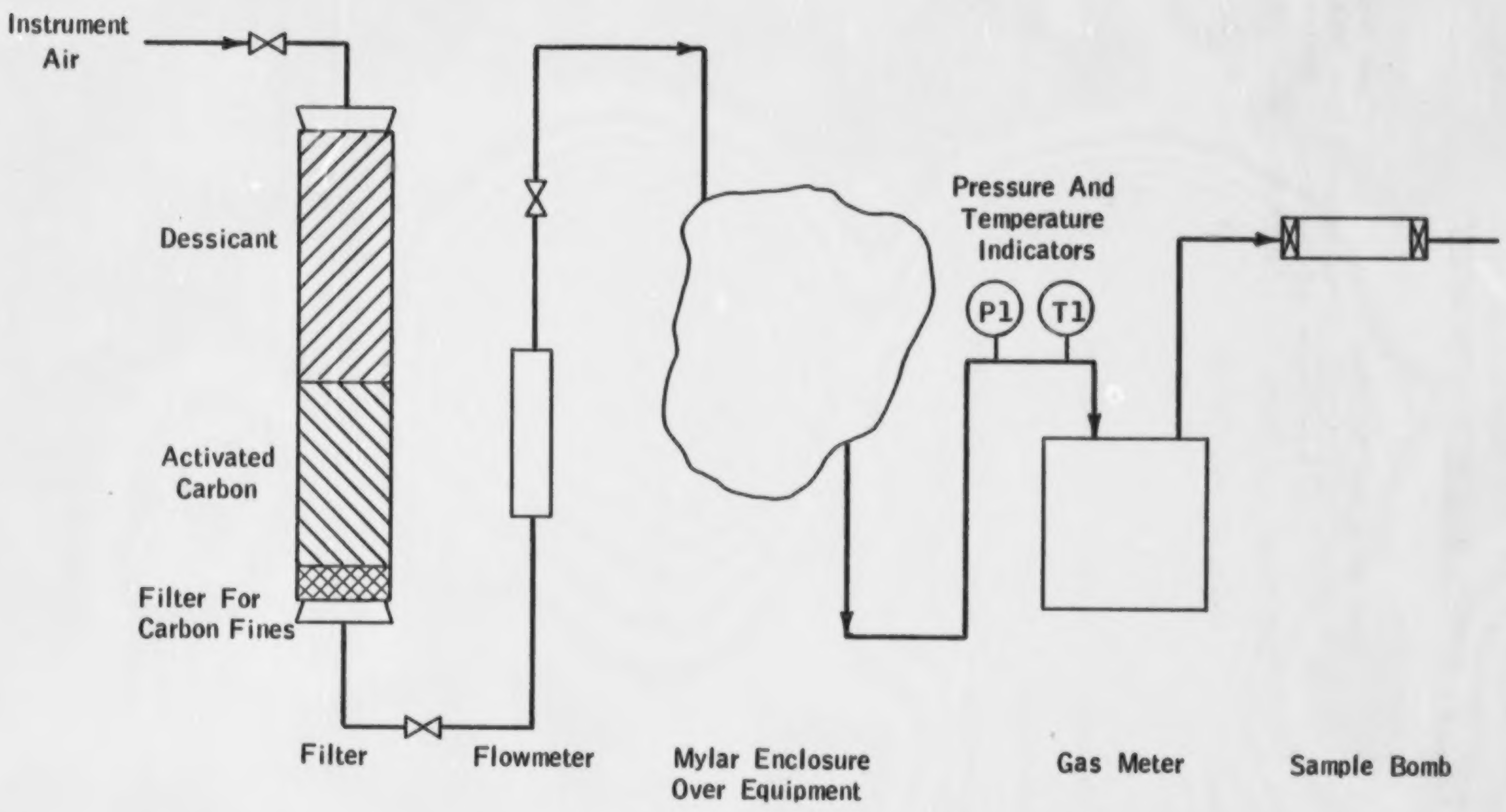
Instrument Air
Dessicant
Activated Carbon
Filter For Carbon Fines
Filter
Flowmeter
Mylar Enclosure Over Equipment
Pressure And Temperature Indicators
P1
T1
Gas Meter
Sample Bomb

Figure 1 - Fugitive Emissions Sampling Train

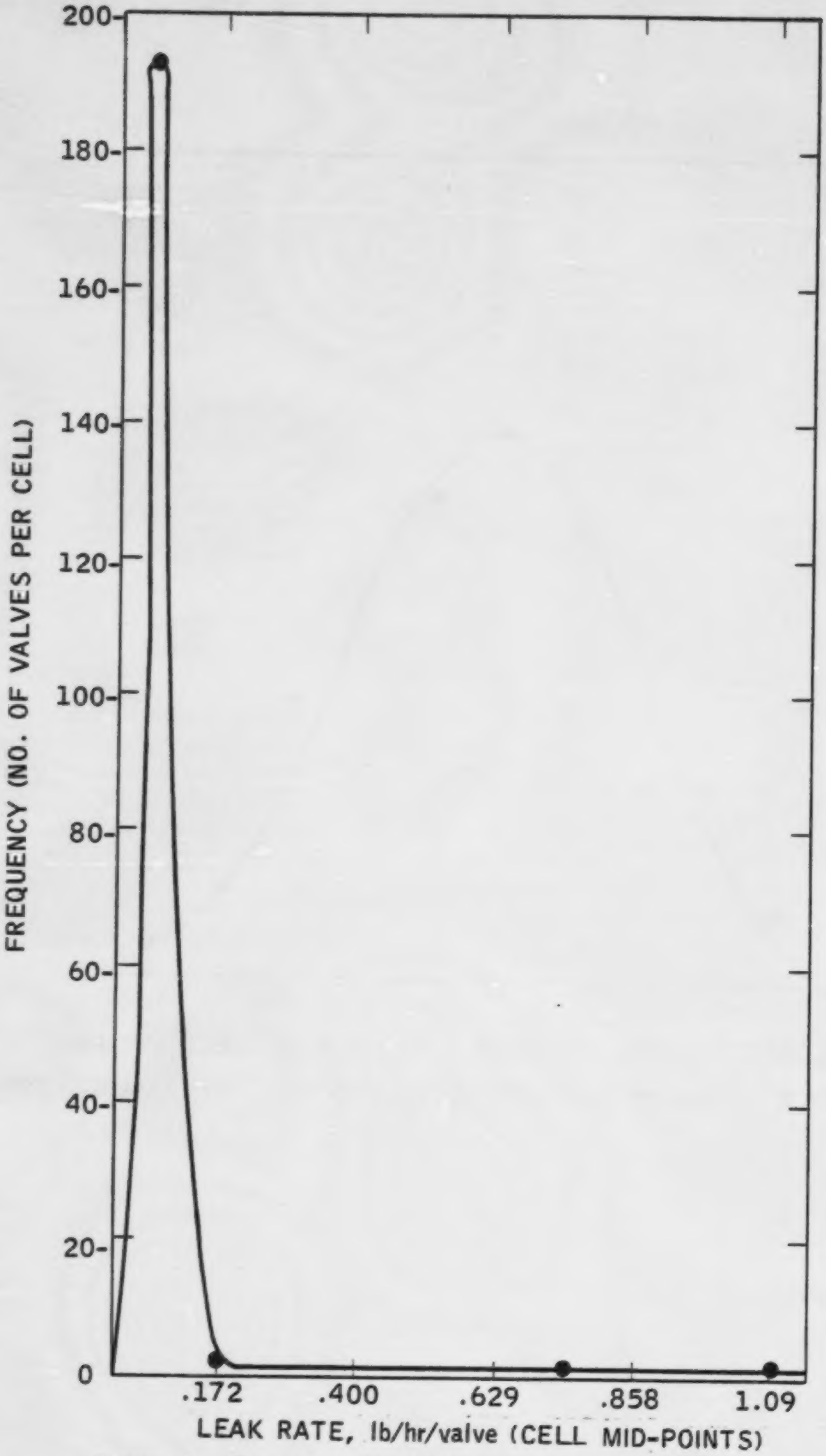

Figure 2 - Frequency Distribution Of Valve Leak Rate Data

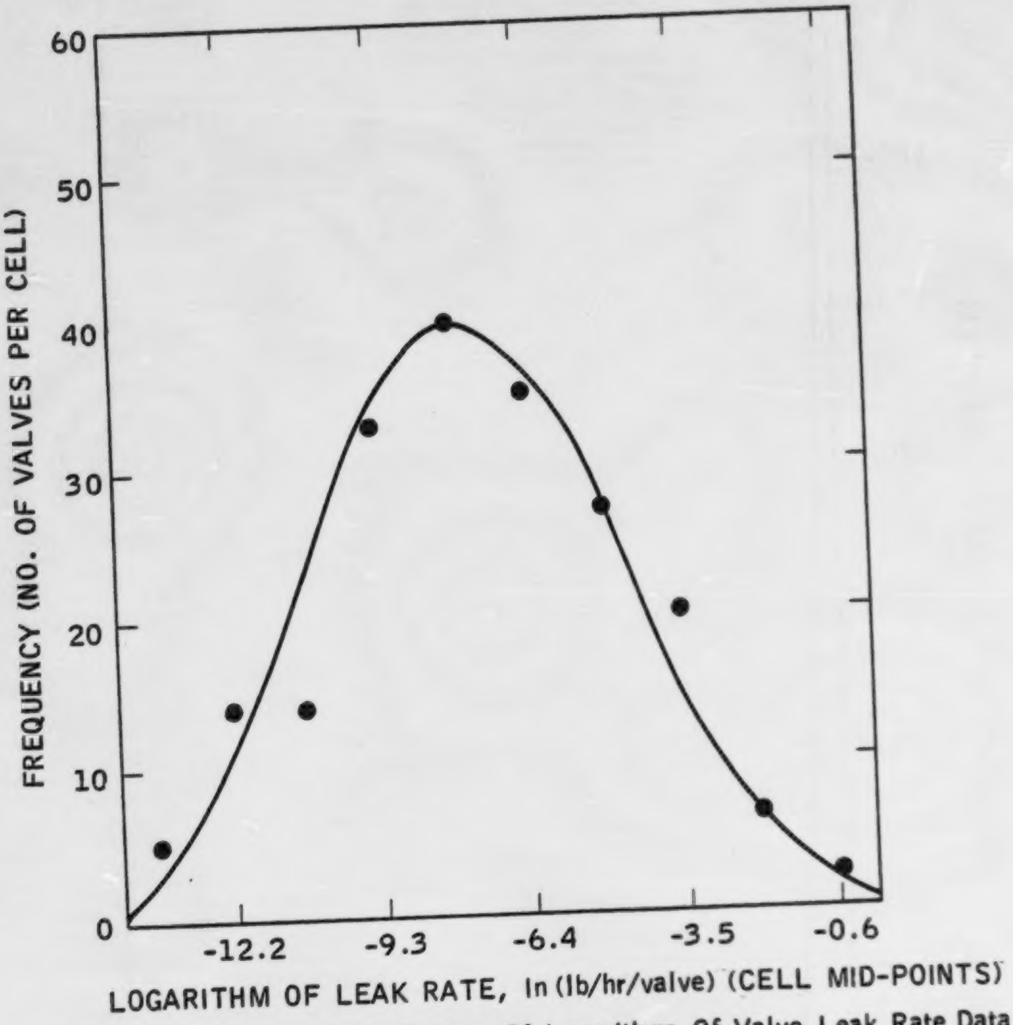

Figure 3 - Frequency Distribution Of Logarithms Of Valve Leak Rate Data

QUESTIONS AND ANSWERS

Q. Richard Vincent, CARB - I was wondering if there were any cost estimates for the three levels of maintenance that you gave results for, in terms of emissions and emission reductions.

A. - We have not sought that sort of information based on this study.

Q. Bruce Beyaert, Chevron USA - You looked at the effective differences among three different product lines. Were there any other differences involved between the product lines, such as gas versus liquid systems, pressure, line size and other things that affect them?

A. - The categories of valves by service, size and pressure, are represented in about the same proportion in each of the product line we looked at.

Q. Charlie Sunwoo, Tosco Corp. - Can you expand on the levels of the maintenance? What you meant by routine maintenance versus special program?

A. - To some extent, yes. The special maintenance program that was in effect consists of inspecting for leaks at a frequency of approximaely once every three to four months. Routine maintenance, I don't want to go into specifics on this particular program, because this was a chemical plant and not a refinery. I don't know that what would be referred to as routine in a refinery would be exactly analogous. I think the main point is that we need to develop categories of maintenance on a broad scale, not from a given facility, but in looking at general industry practices, and to use this information to attempt to correlate the data that is being gathered.

Q. Rex Smith, Xomox Corp. - I think everything is being attributed to maintenance. Study ought to be given to proper valve selection because, of course, this can affect the maintenance factor. If the valve is improperly applied, it can be a high maintenance item. This entire factor, I think, has been completely disregarded.

A. - In this particular study, because the different product lines are at the same facility, the means used for selecting the type of valves would be approximately the same from one area to another. So, I don't think that valve selection is a significant variable in this particular study.

Comment - Rex Smith, Xomox - Maybe not a variable, but it might vary the maintenance features on the particular valve selected. And, possibly the selection of valves may or may not have been correct.

A. - That is certainly true.

Q. Paul Harrison, MRI - We are talking about existing facilities and the problem of how to correct something as opposed to installing new technology. I would like to say that your approach, Karen, is whole-heartedly endorsed. My paper will talk about the same thing, categorization; choosing from a selection of leaking components, as opposed to trying to look at the whole thing as statistical. The selection process is virtually impossible and the probability of gaining a good statistical distribution of leakers is highly improbable. You did it right, and I think that's great.

Q. Richard Vincent, CARB - I was just wondering if you or anyone has any idea of what the relative importance is of fugitive emissions just from valves, pumps, etc. from chemical plants and other industrial sources, other than refineries?

A. - I would hope that after we see the results of some of the refinery studies being done, we could go back and compare these results and get a feel for it. On the basis of one chemical plant study, however, such information couldn't be developed.

Q. Richard Vincent, CARB - I guess I am looking for a valve count of all the valves that are relative to how many of them are in refineries?

A. - That information I wouldn't have.

Q. - What chemical plant was this? What type of chemical plant? You didn't mention that.

A. - That is right, I didn't name the specific facility.

DETECTION AND CLASSIFICATION OF FUGITIVE COMPONENT LEAKS

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ABSTRACT

After surveying four separate facilities for component leaks, it has become apparent that less than six percent of the components account for more than 90 percent of the fugitive emissions from all components. Due to the large variance of emission rates, rigorous statistical selection from a representative arithmetic average is highly improbable. Subclasses must be secured by total facility surveys. Each class will have its mean where the geometric mean is much closer to the arithmetic mean than it would be in the total distribution. For similar throughput refineries, the difference in number of component leakers is a factor of two for newer versus older facilities which could be inferred to reflect maintenance activities. The survey technique seems not to be critical except for classifying the component as to Class I (worst case) to Class IV (insignificant leak). The close in sample is preferred and helps to negate geometry and wind effects.

Use of transects can characterize the total fugitive emission rates by use of meteorology and hydrocarbon analysis. Verification by component leak rate measurements have occurred, with the results showing that "areas of emissions" such as spills, sewers, etc. which are related to component leaks are nearly or equally as important as the components themselves. However, eliminating the component leaks usually eliminates the "area emissions" (evaporation).

The data for these conclusions are contained within this paper.

RESUME

Paul Harrison has been with MRI since 1974 where he is a Department Manager. During this time he has done work in the area of fugitive emissions from petroleum refining. From 1970-1974, Dr. Harrison worked for the City of Chicago where he was Director of Technical Services in the Dept. of Environmental Control. Paul has a Ph.D. in Air Pollution Atmospheric Sciences and a Master's Degree in Meteorology, a Master's Degree in Computer Information and Control Engineering and a Bachelor's Degree in Physics which is a very impressive background.

P. R. Harrison

DETECTION AND CLASSIFICATION OF FUGITIVE COMPONENT LEAKS

INTRODUCTION

This paper describes some results of work performed on various types of hydrocarbon treatment and petrochemical facilities. The methods have been developed to a nearly routine protocol between the years of 1975-1978. These detailed protocols are beyond the scope of this report. Most of the impetus for this work was the need to lower hydrocarbon emissions to acceptable levels and/or "trade-off" requirements in a nonattainment (ozone) area. In all cases, the method has been accepted by the agencies involved and the reduction/construction phase in some cases is pending final permits. Much of the assessment calculations made to date are dependent on emission factors based on throughput, or component type, or number. Our studies show that for identical throughputs the percentage of components leaking and total fugitive emissions are dependent on age, maintenance, total number of components, and product type. There is less relationship to throughput and size of component.

For some time there have been known inaccuracies in emission inventories due to the lack of knowledge of the fugitive part of the calculation. Although a study was conducted in the 1950s, resulting in component factors such as 0.5 pounds/day for valves on, later studies resulted in 5 to 28 pounds/day/1000 barrels capacity, depending on component type. (The latter number is for valve emission rates.) Needless to say, there has been a great deal of controversy surrounding these values and their use as average or state-of-the-art controls. The argument would have remained academic if not for the discovery that most of the country was in violation of the primary ozone standard which made them Class I or nonattainment areas. This secondary pollutant is heavily linked with nonmethane hydrocarbons (NMHC). Recent legislation has also mandated trade-offs for new, improved, or expanded facilities with penalties over one-to-one trades (add 20% in California). Thus, the fugitives become an abatement area as well as a valuable asset for trading.

The multiple tasks remaining were to:

1. Identify the total amount of hydrocarbon emitted
    a. Isolate the fugitives
    b. Determine the nonmethane fraction
2. Identify the component type and size of leak
    a. Correlate with throughput, size, product, etc.
    b. Compare the number and size of component leaks with total number and type of component

    c. Resolve the component fraction with the total fugitives

3. Suggest a control strategy
    a. Consider economics, manpower, and technology for maintenance
    b. Number needed to be controlled for trade-off needs
    c. Amount of control needed for compliance
    d. Formulate institutional changes to assure maintenance
    e. Consider maintenance of these desired rates

To date, we have accomplished the techniques to accomplish each subtask, except 2a and 3a. These tasks are less technical and more management related but can easily be assessed given the information available from the other tasks. Based upon experience to this point, the correlations are not as important as the others and the economics are greatly favorable.

The main objective of a fugitive emission study is to estimate the rate at which total hydrocarbons are being emitted from the numerous fugitive sources located in a refinery prior to the Directed Maintenance Program. To make this estimation with a reasonable degree of accuracy, it is necessary to determine to what extent, if any, emissions from elevated sources (flares, cooling towers, etc.) and process variations contribute to hydrocarbon concentrations used in calculating the fugitive emission source strength. These factors are a pacing factor in estimating the absolute accuracy of the abatement program. The repeatability of the results of the diffusion calculations, especially under similar meteorological and emission conditions, is very good. By judiciously taking grab samples for subsequent chromatographic analysis the nonmethane fraction and instrument calibration is found.

An alternative procedure would be to measure a large number of individual components and statistically project the reduction. This procedure is very time consuming and expensive. Even though the statistical procedure may seem rigorous, it may not represent reality. The explanation for this contradiction is the large skewness of the actual distribution toward the few largest leaking components. The distribution extends over several decades. Figure 1 is a semi-experiential estimate of the actual distribution of leaking components found in a "typical" facility. One can see that a few leakers over the last five decades on the plot account for as much in total emissions as those in the first five even though the median is around the third (10^{-2} g/hr) (i.e., one component leaking at 100 g/hr accounts for 10,000 at 10^{-2} g/hour). The probability of randomly selecting these two components in 10,000 plus components is very small. The best solution to the probable errors inherent in the statistical selection is to categorize the components into significant, small, medium, and large classes by a complete survey and select a group randomly from each category to find a probable class median.

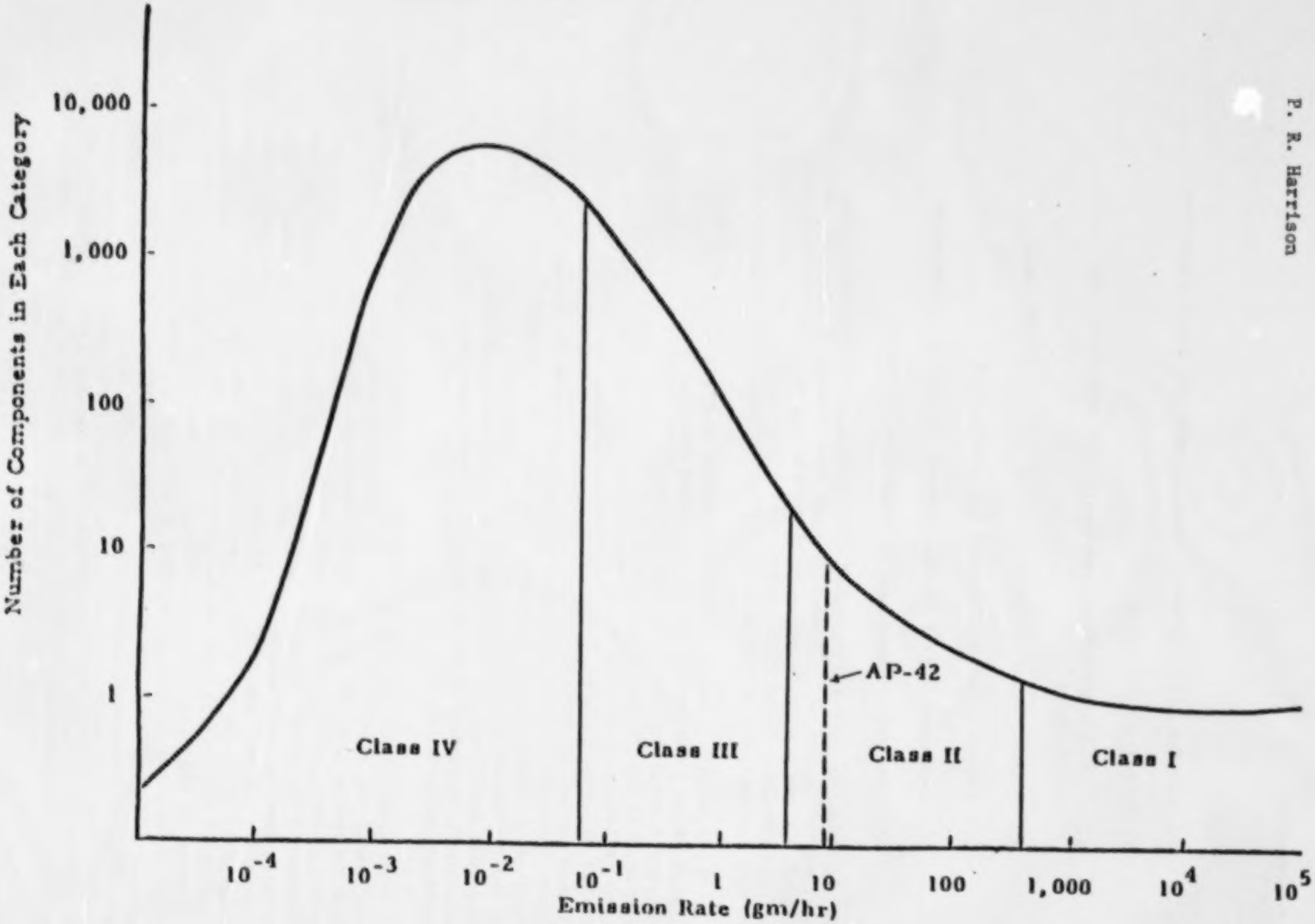

Figure 1. Semi-experiential plot of distribution of leak/emission rate of component in a "typical" hydrocarbon facility.

Again, this procedure is much more accurate for the component fraction but does not lend itself to routine measurements and enforcement due to time and/or expense considerations. Finally, some of the fugitives are area sources such as spills, liquid component leaks, and sewers. The first choice to characterize by transects is easily the most rapid and inexpensive method of obtaining the total fugitive emission rate. It is also probably the most accurate.

RESULTS

Percent of Component Leaks Related to the Total Number

Of the four facilities, two happen to be moderately large refineries located in different areas of the United States. Each has virtually the same capacity and throughput. Table 1 summarizes these results. The older facility has six percent classified above the insignificant leak rate (0.01 lb/day) and the newer facility is 1.9 percent. Thus, the rates differ by a factor of three due to age and possible maintenance practices. In addition, the older facility produces a higher percentage of gaseous hydrocarbons (lights). By repairing all the Class I and II leaks they could possibly obtain average leak rates of less than 0.0014 and 0.002 lb/day per component (500 and 3200 components, respectively) for the newer and older facility. This close agreement is an indication of the leverage of the larger leak rate components on the total rate. In fact, after Class I maintenance the average component leak rate is substantially reduced by a factor of nine to tenfold.

TABLE 1. DISTRIBUTION BY PERCENT OF LEAK RATES FOR TWO FACILITIES OF SIMILAR THROUGHPUT

	Class				Total Number of Components
	I (%)	II (%)	III (%)	IV (%)	
Older Facility	2.0	2.0	2.0	96	80,000
Newer Facility	0.3	0.7	0.9	98	50,000

Figure 2 presents a cumulative distribution of components for the newer facility. These results reinforce the conclusion that a rigorous one class component selection procedure is not advised.

Detection and Classification Techniques

By use of a classification technique we must operationally define the ranges and methods in sufficient detail to be quantitative but not so restrictive as to be unacceptably difficult (expensive). Factors such as accessability, wind speed and direction, and probe distance relative to the component are important. In order to investigate the sensitivity of some of these factors we conducted some simple experiments.

Figure 3 is a sketch of a four-inch valve that was classified as a Class III leaker (yellow). Table 2 is the result of this test. Figures 4 to 6 present plots of these data. The impetus for these tests is to equate the MRI method with a proposed EPA method. We see that the closer one takes the survey the higher the concentration becomes, but in general, the difference between maxima and minima become less, except for very brief excursions. This fact, coupled with the ease of classification by actually physically touching the probe extension to the valve stem makes the task more efficient. Each method is acceptable as long as one has an order of equivalence between the methods.

Use of Transects for Measurement of Total Fugitive Emission Rates

As mentioned earlier, fugitive emissions are mostly related to component emissions. There are other sources identified by the characterization techniques that are area sources not easily quantified by individual measurements. These must be assessed by transect measurements. By use of classical diffusion analysis one can assess individual areas as well as the total facility. After securing constituent analysis of the grab samples one can determine the nonmethane fraction and the hydrocarbon mix calibration factors. Combining these three data points one can calculate the NMHC emission rate of the total facility or any subset.

The method has better than 10 percent precision under constant emission activity and availability of an optimum transect line. Under dynamic conditions with no control of activities and a facility-edge transect line the precision can drop to 50 percent, most of which seems to be caused by changes in activities, not the method. In most cases, the precision is better than 20 percent. The accuracy is most effected by the constituent analysis factors. The instrument calibration holds well over a length of time to better 10 percent if the temperature is not radically changed.

The calculations use meteorology in such a way that only the vertical diffusion parameter is assumed from statistical tables. All other parameters are measured by objective means. An example of a surface transect is shown in Figure 7. For a more positive plume profile measurement several transects

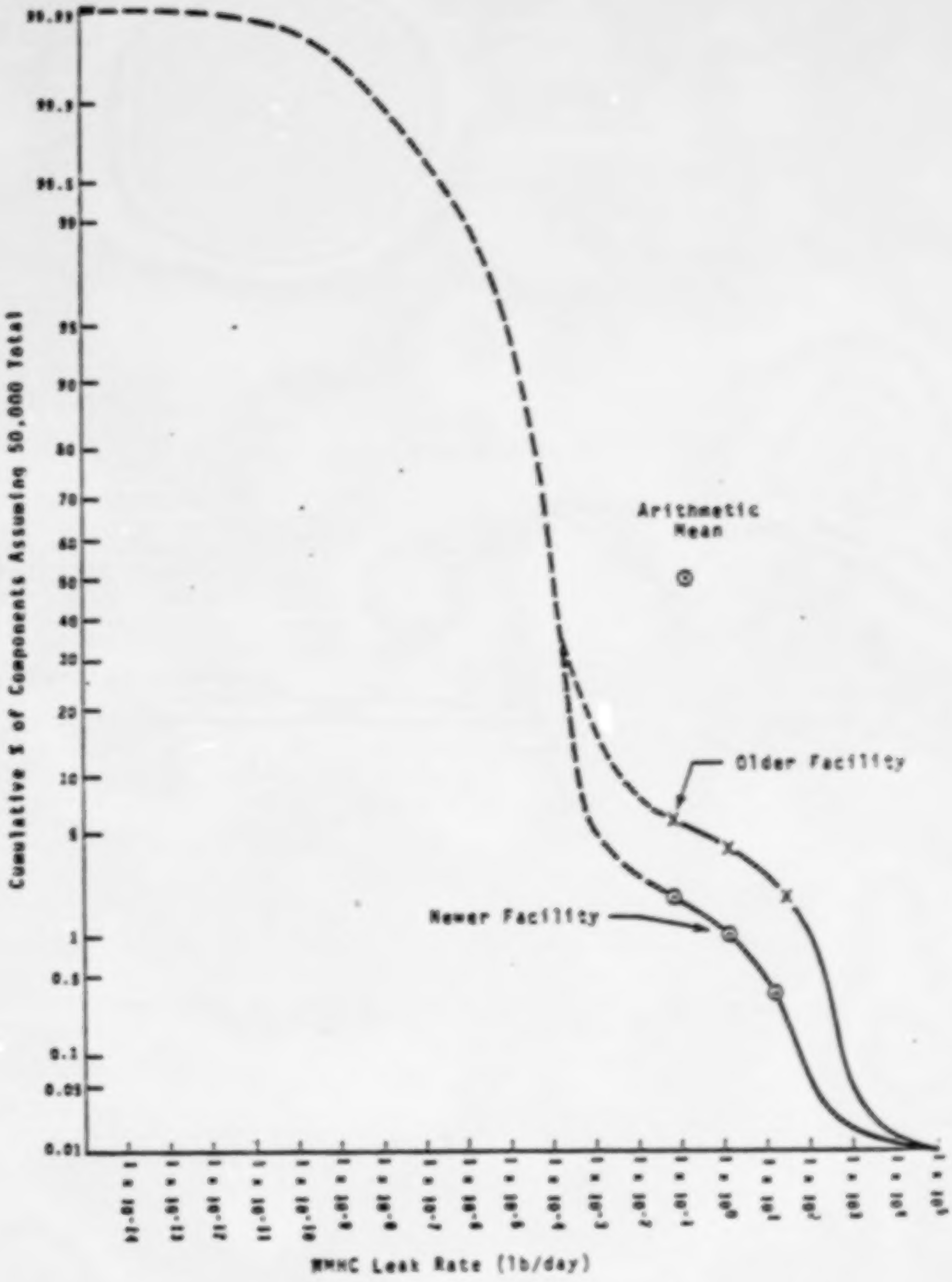

Figure 2. Cumulative distribution of components with respect to leak rate.

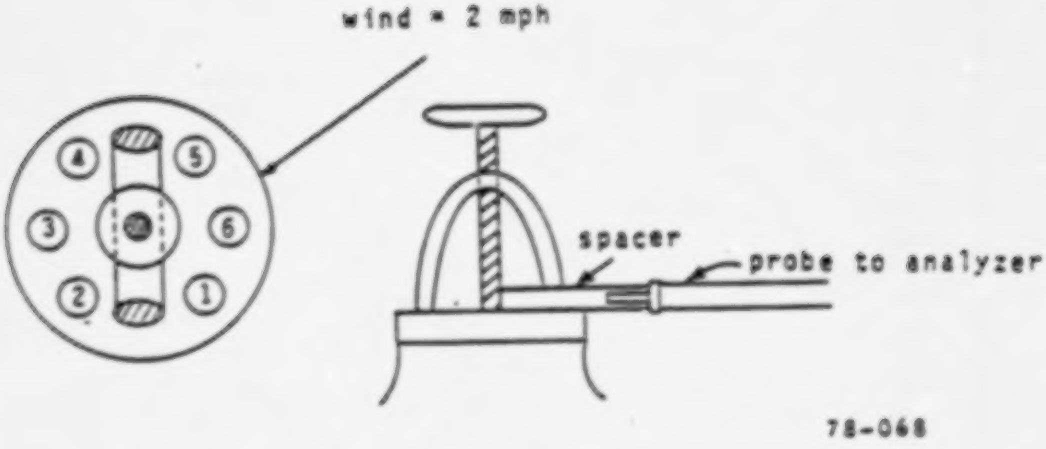
wind = 2 mph
4
5
3
6
2
1
spacer
probe to analyzer
78-068

Figure 3. Schematic of valve showing sampling positions.

TABLE 2. VALVE DISTANCE STUDY

Measurements Were Taken Horizontally From Valve Stem
As Noted at Level of Packing Surface Except for *.

Please See Figure 3.

() Values are Minimum and Maximum Values at That Position

	Position					
Distance (cm)	1	2	3	4	5	6
5	250	150	20	15	15	50
	(80-1200)	(90-900)	(15-800)	(10- 60)	(10-500)	(30-100)
2.5	250	200	30	15	25	30
	(100- 800)	(150-600)	(15-800)	(10- 30)	(15-50)	(15-50)
0	(700-2000)					
0*	700			100		
	(400-200)			(40-400)		

Ambient = 20-40 ppm

Wind = 2 mph, gusting to 5 mph

*1 cm above packing

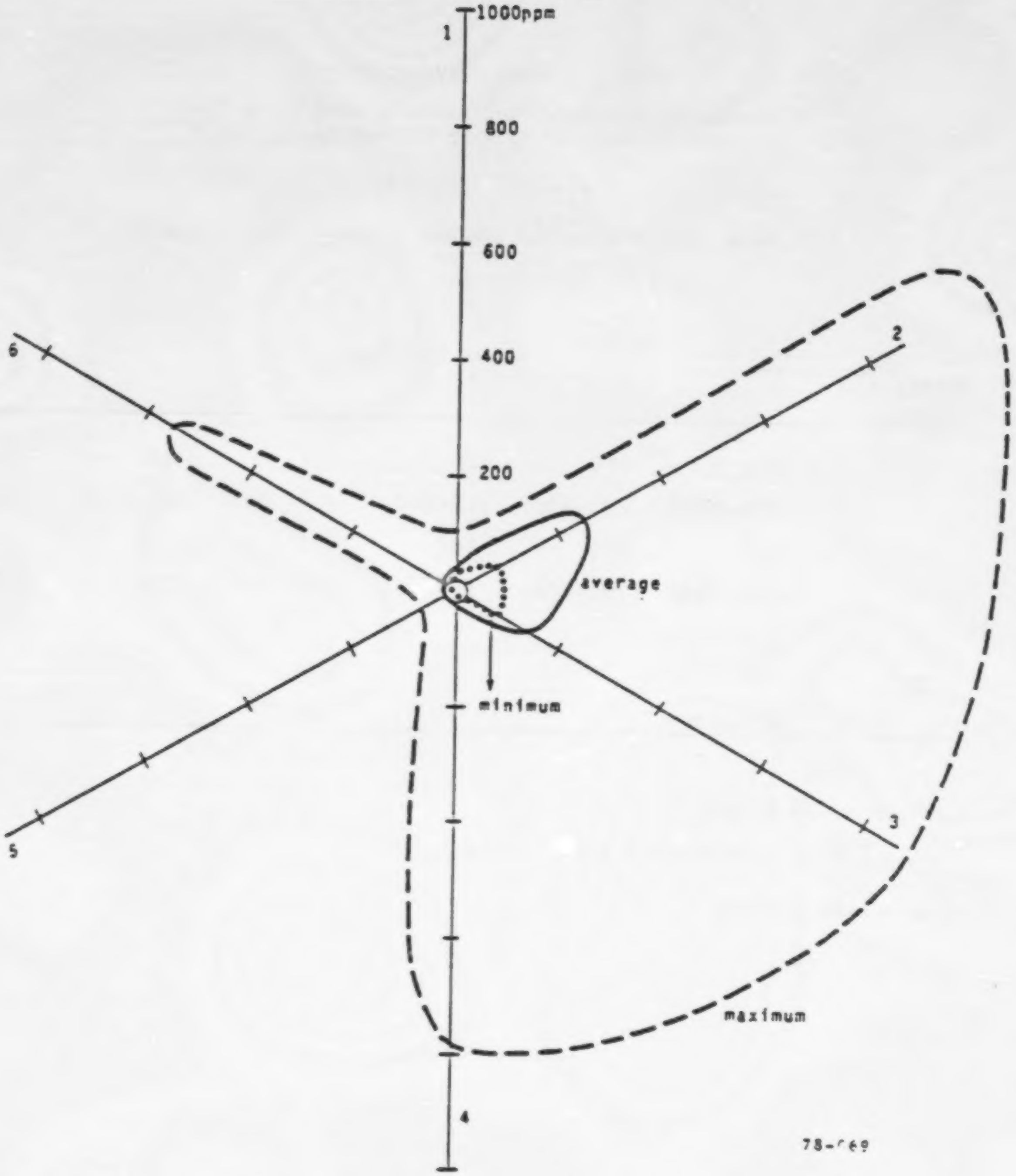

Figure 4. Concentration around a valve stem at 5 cm horizontal distance from packing.

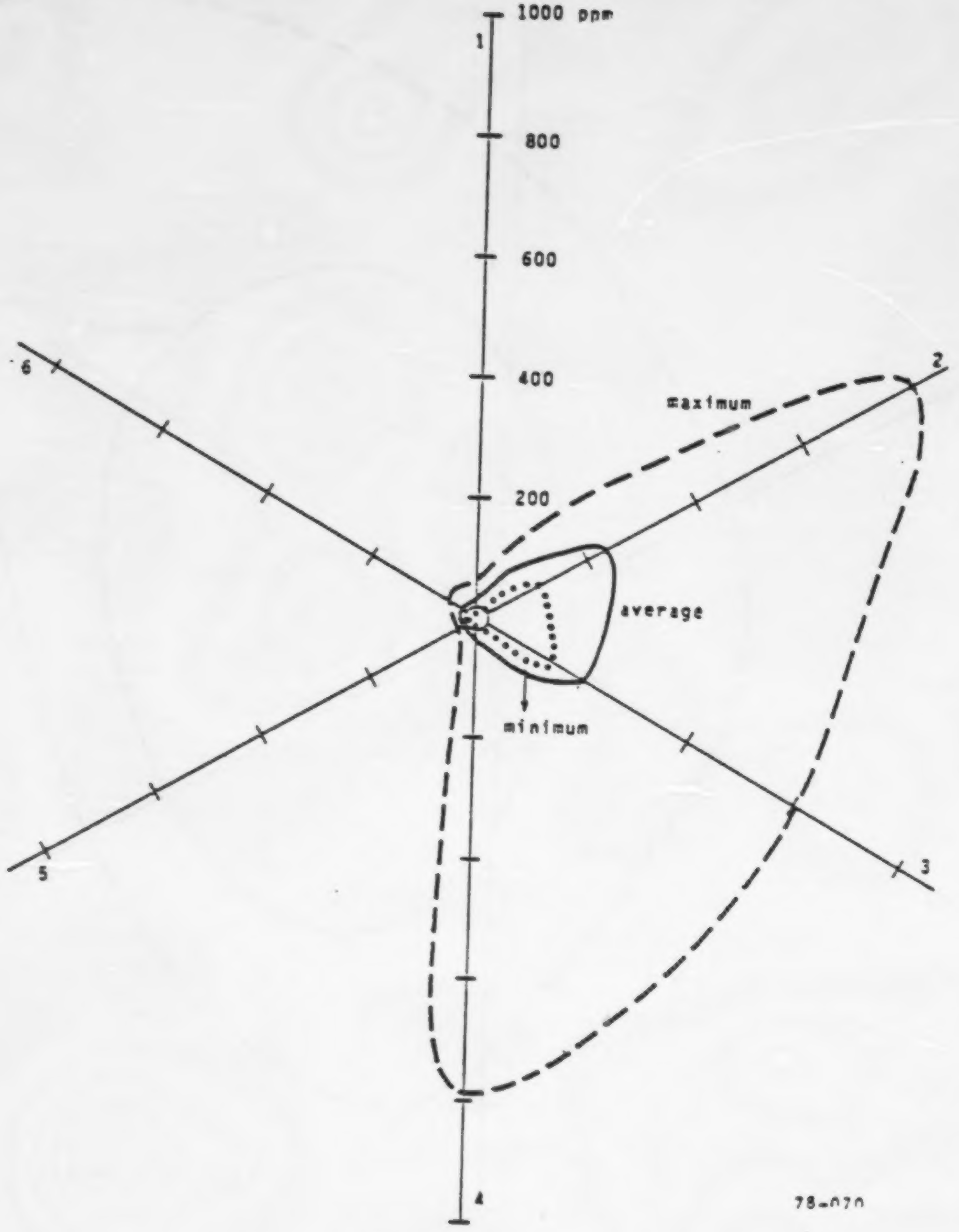

Figure 5. Concentration around a valve stem at 2.5 cm horizontal distance from packing.

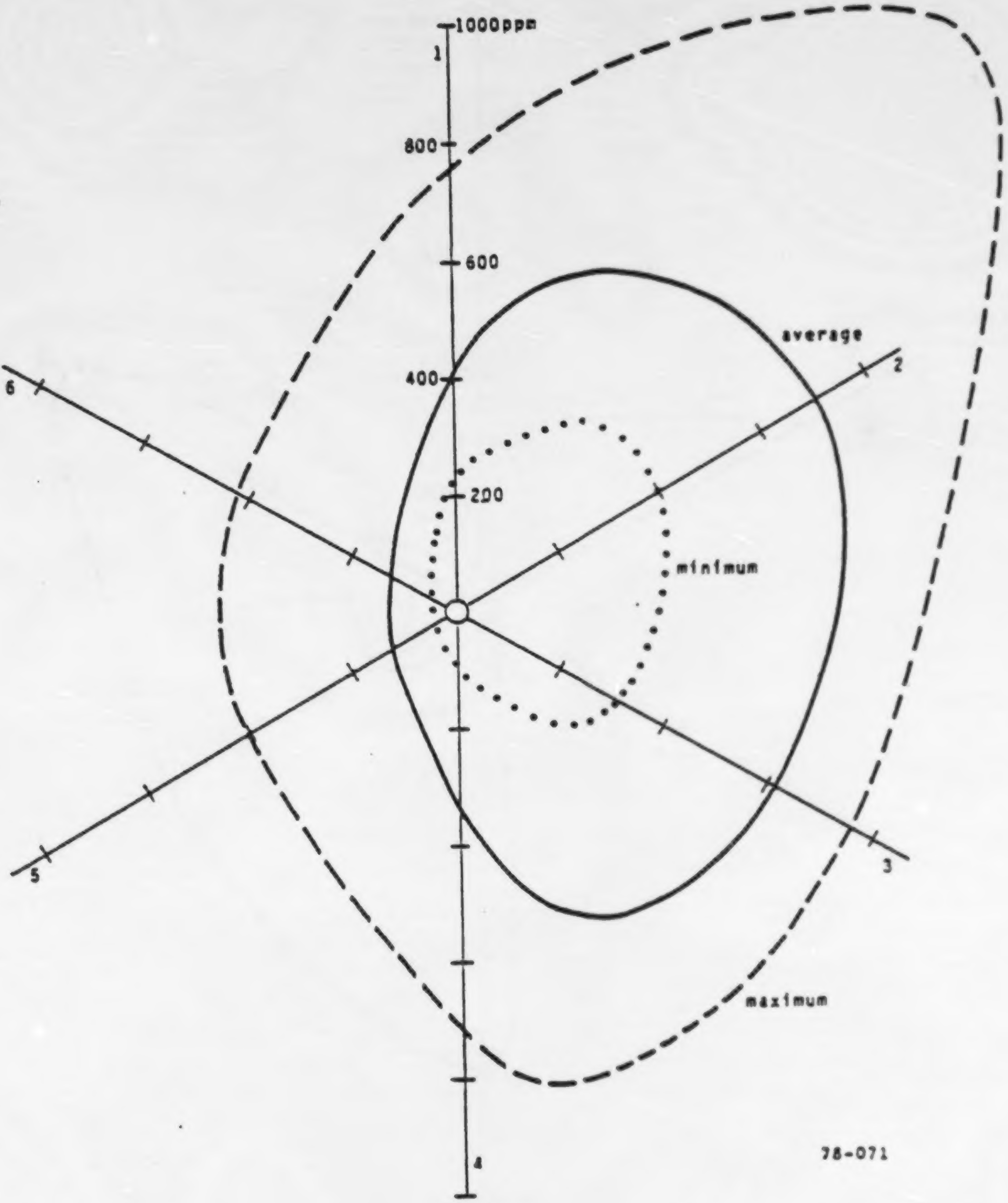

Figure 6. Concentration around a valve stem at the stem and 1.0 cm above packing.

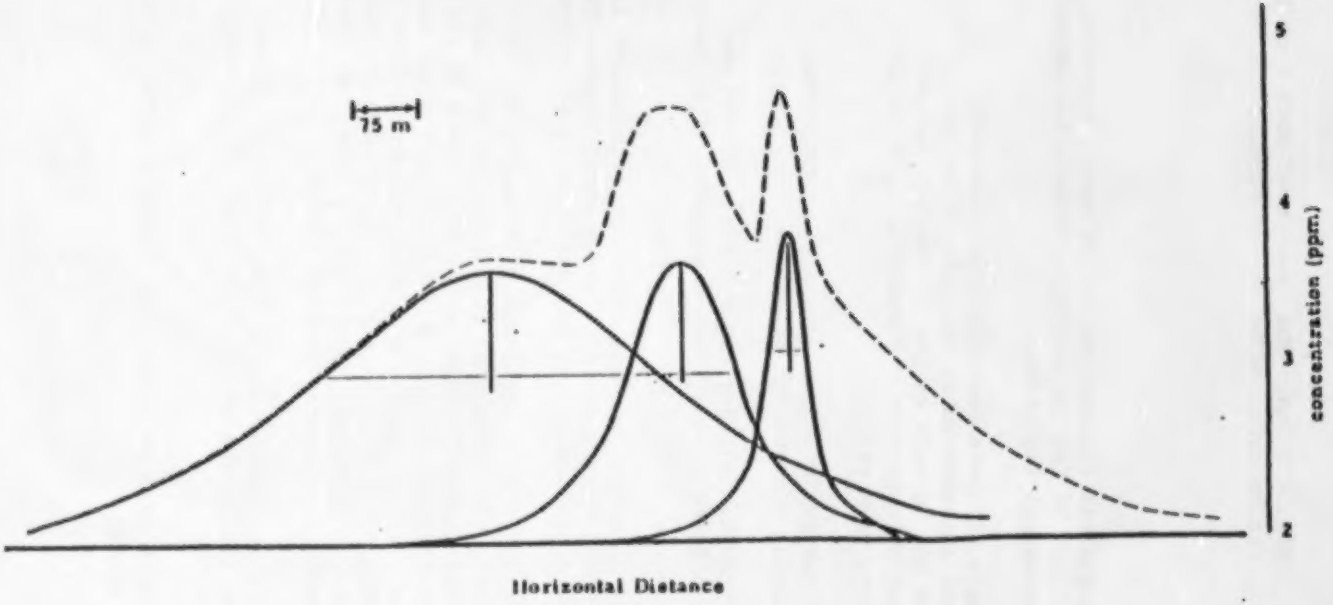

Figure 7. Average hydrocarbon concentrations obtained downwind of a refinery on 19 July 1977, 2000 to 2200 CDT. Solid lines represent computed Gaussian plume components.

in height are made. Figure 8 shows the results of such a method. Similar but inferior results can be obtained by use of fixed point vertical profiles (see Figure 9).

CONCLUSIONS

The following general conclusions can be made concerning the techniques and knowledge developed so far for fugitive hydrocarbon emissions from refineries and petrochemical facilities:

- A reasonably accurate assessment of nonmethane hydrocarbon emission rates for subsets or total facilities can be made by use of the MRI transect methods and calculations. Precisions up to eight percent have been reached.

- Component surveys require a classification scheme for meaningful statistical selection.

- Initial component surveys require three to six man-months to achieve. Less time is required after maintenance.

- Results of component surveys show that significant leaks constitute one to six percent of the total components available, depending on age and maintenance practices.

- Subsequent individual measurement of leak rates of randomly selected components indicate that the Class I components (large leakers) constitute about 80 percent of the total component fugitive emissions. After maintenance on Class I leaks the average component leak rate is less than AP-42 by a factor of ten or more. After maintenance on combined Class I and II leaks the average rate is reduced by another factor of ten.

- Until these techniques become Best Available Control Technology (BACT) the methods can give considerable trade-offs.

- The remission rate of fixed components is slow, on the order of months.

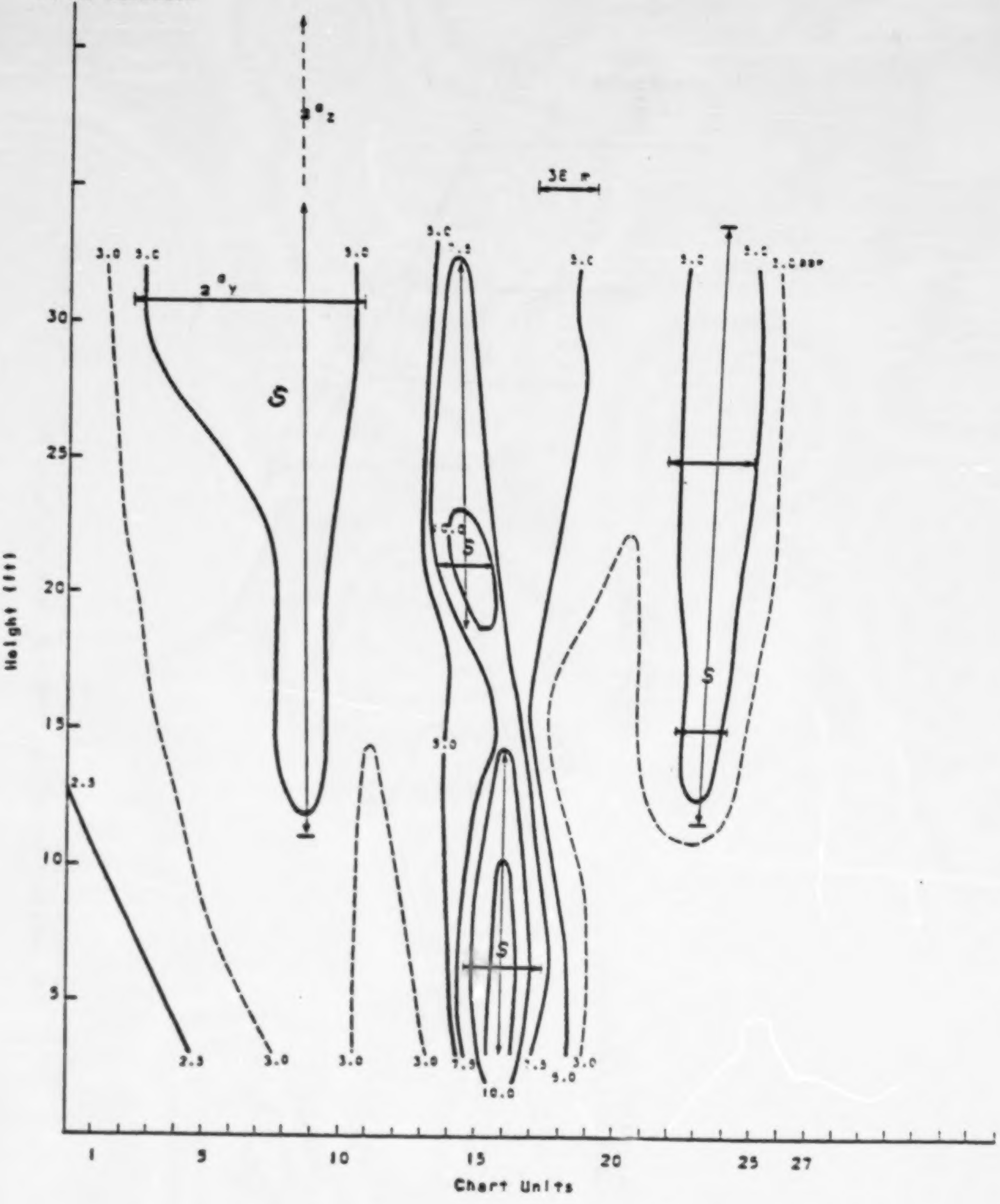

Figure 8. Example of vertical cross section, 20 October.
All data are in ppm.

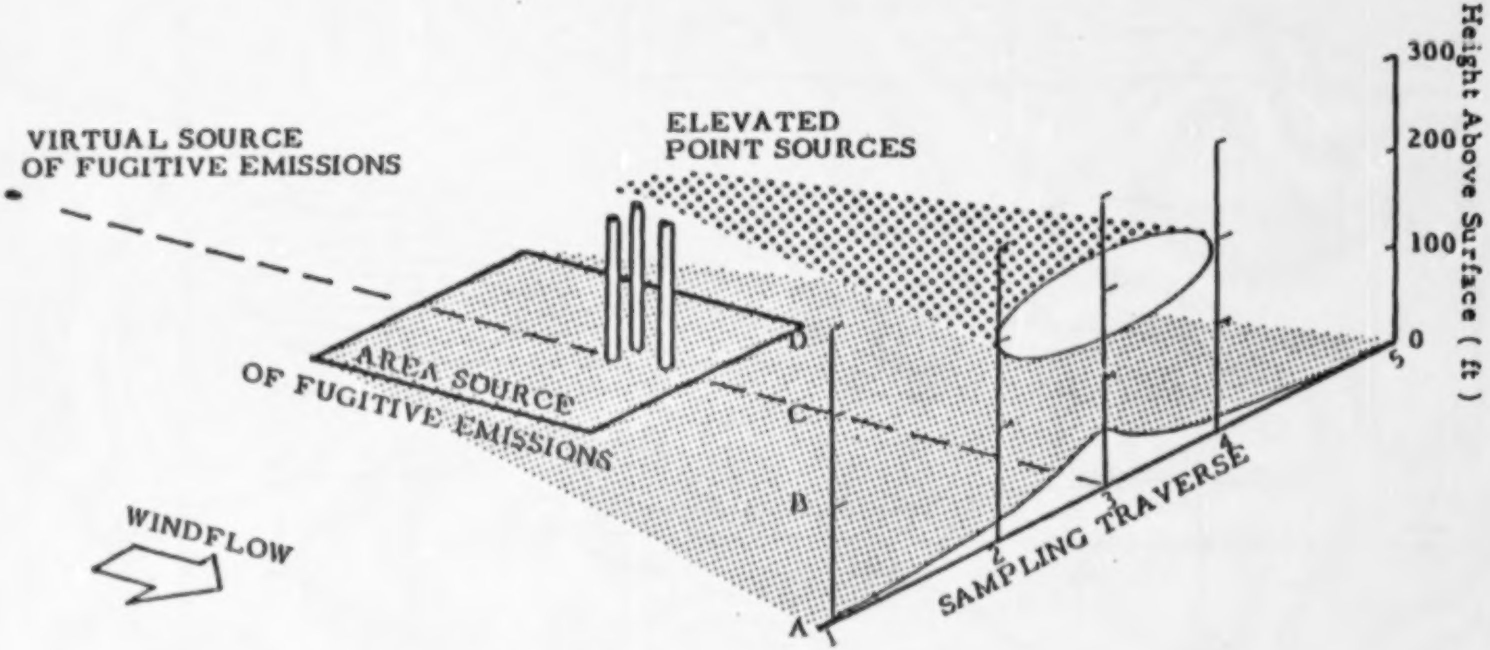
Height Above Surface (ft)
300
200
100
0
VIRTUAL SOURCE OF FUGITIVE EMISSIONS
ELEVATED POINT SOURCES
AREA SOURCE OF FUGITIVE EMISSIONS
WINDFLOW
SAMPLING TRAVERSE
A
B
C
D
1
2
3
4
5

Figure 9. Schematic representation of vertical point profiles (1, 2, 3, 4, 5) and elevated horizontal transect lines (A, B, C, D).

QUESTIONS AND ANSWERS

Q. Bob Kenson, TRC - The fact that reproducibility was very good on the horizontal traverse at the fenceline doesn't say anything about accuracy does it?

A. - How do you measure accuracy when you have nothing to measure against? So, I take a measured factor but I don't choose to represent it as any accuracy because I can't calibrate that accuracy. What I can do is to go through and do this relatively detailed component classification and measure the leak rate and use this equivalency to see how it compares with the fenceline measurement. In one case, it was within 75% which is good considering that there are contributions from non-fugitive sources. Other cases haven't done that well. In all cases it is always less than the fenceline measurement which is encouraging. My biggest problem is finding a laboratory that will give me a reproducible hydrocarbon constituent analysis.

Q. Bob Kenson, TRC - The second part of my question relates to the airplane traverse, were they able to show you the term σ_z, and were they anything reasonable?

A. - The purpose was not to measure elevated plumes. As far as the fugitives are concerned, they are mostly a ground-level type source system. The Turner factors were acceptable within the 20% that we claimed. This is over flat terrain.

Q. Hal Taback, KVB - During the program that I reported on earlier, we made an attempt to measure the emissions from a refinery using upwind/downwind techniques and the results were not in very good agreement with the technique we used for point source or source type testing. What we did, in this small refinery, is to have a source test crew in the refinery at the same time as an ambient crew on the fenceline and they used the techniques with the sulfur hexachloride for trying to trace the wind patterns. And with that they predicted the diffusion and actually from the fenceline measurements, they back calculated the emission factor. The result was that there was about 10% correlation. There is a final report associated with that program which should be out soon. We thought that perhaps our ground-level measurements were missing a lot of emissions that were going up.

A. - It depends on your release point. If you release in a warm area it is possible that you are missing it. That is why you should do at least one elevated transect, especially when you are using it as a point of reference. You must do elevated transects in order to get that maximum value. We have seen no contradictions to the fenceline. Not a single case in which it could not make sense, where in your case you don't seem to have enough at the fenceline.

Comment - H. Taback, KVB - In the first chart you showed, you had the AP-42 prediction but the fenceline measurement was substantially lower.

A. - The actual survey did verify the fenceline measurement; in that case it verified very well, but in a very small facility.

Comment - In that facility you did not have tanks, because when you are at the fenceline of most facilities you were picking up tanks and other sources of emissions.

A. - In most cases, we were able to isolate the tanks. The tanks were downwind of us. One critical thing, of course, is to judiciously choose your transect line and that is an experiential thing. I would caution you that, (myself being a meteorologist) many times one will hire meteorologists to do diffusion analysis. Even within the field of meteorology, diffusion analysis is a specialized field. A modeler himself may not understand synoptic conditions and may not be able to direct a field program as well as he can direct a computer program. Thus, the choosing of the fenceline transect is critical.

FUGITIVE EMISSION CONTROL STRATEGIES FOR PETROLEUM REFINERIES

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Environmental Protection Agency

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ABSTRACT

In a study funded by the Environmental Protection Agency, measurements of hydrocarbon emissions from fugitive sources are being made at a number of refineries throughout the country. Sampled sources include valves, flanges, pump seals, compressor seals, relief valves, process drains, cooling towers, API separators, and dissolved air flotation units.

In this paper, strategies are presented for the control of fugitive hydrocarbon emissions from the various refinery sources. Emissions from these sources in existing refineries are estimated from the results of sampling at six refineries. The potential for emissions reductions with the proposed control strategies is presented.

DETECTION OF VOLATILE ORGANIC COMPOUND EMISSIONS FROM EQUIPMENT LEAKS

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ABSTRACT

The body of information presented in this paper is directed to air pollution control agencies and refinery and chemical plant operators concerned with limiting volatile organic compound (VOC) emissions from equipment leaks. Equipment that may emit VOC as a result of leaks includes pump seals, compressor seals, valves, flanges, pressure relief devices, process drains, and cooling towers. Four methods of leak detection are discussed. The first three utilize a portable VOC detection device (flame ionization detector) and the fourth a fixed monitoring system. For all of the methods an elevated VOC concentration is indicative of an equipment leak. The first detection method consists of using the instrument to sample the ambient air in close proximity to each potential leak source. In the second method, the VOC detector is used to traverse a unit upwind and downwind of all major ground level sources. Only the unit boundary is surveyed in the third method. In the fourth method, fixed monitoring systems are used to detect elevated VOC concentrations or to monitor equipment performance. After a leak is located, maintenance can be performed and VOC emissions to the atmosphere reduced.

RESUME

K. C. Hustvedt is an Environmental Engineer with the EPA in Durham with the Office of Air Quality Planning and Standards. K. C. is responsible for the development of guidelines and regulations for the control of volatile organic compound emissions from the petroleum industry. He received his B.S. degree in Civil Engineering from Duke University in 1975 and is an Engineer in Training in North Carolina.

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* Speaker

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DETECTION OF VOLATILE ORGANIC COMPOUND EMISSIONS FROM EQUIPMENT LEAKS

INTRODUCTION

This paper outlines four monitoring methods that have been used to locate leaks of volatile organic compounds (VOC) from petroleum refinery and chemical plant equipment. Equipment that is prone to develop leaks includes pump seals, agitator seals, compressor seals, valves, flanges and other connections, and pressure relief devices. Process drains and cooling towers can also emit VOC because of leaks into the water from faulty equipment or through improper operation. Although the average leak rate is relatively low, these leaks can be a significant source of VOC emissions to atmosphere because of the very large number of equipment components. For example, a 15,900 cubic meter per day refinery would have about 27,000 potential leak sources, and a 22,700 megagram per year maleic anhydride plant would have about 500, excluding flanges in both cases. Past and present testing of petroleum refinery and chemical plant equipment has shown that, while leaks from most equipment are insignificant, a small percentage can have high leak rates. This situation highlights the importance of developing an effective leak detection plan. Combinations of the four methods described in this paper can be used to locate leaking equipment, so that timely repairs can be made and emissions of VOC to the atmosphere reduced.

DESCRIPTION OF THE EMISSION SOURCES

There are several types of equipment found in petroleum refineries and chemical plants which can leak and, therefore, emit VOC to the atmosphere. VOC are emitted directly to atmosphere from vapor leaks and indirectly when liquid leaks evaporate. Equipment that can leak includes; pump seals, agitator seals, compressor seals, valves, pressure relief devices, flanges and other connections. In addition, there can be VOC emissions from cooling towers as a result of leaks through heat exchangers into the cooling water. Improperly designed or operated process drains can also be a source of VOC.

Finally, are several miscellaneous sources of VOC in such facilities, generally from wastewater streams contaminated with organic material, however, these sources are not addressed in this paper.

In pumps, agitators and compressors, the leak occurs between the moving shaft and the sealing element. These sealing elements include compressed packings and finely machined surfaces (as in mechanical seals). Leaks in flanges occur through or past the gasket material. Emissions from process drains occur when organic materials are allowed to collect before the trap and thus are exposed to the ambient air. For the most part, organic compounds in cooling water result from leaks in heat exchange equipment.

Emissions from pressure relief devices can be of two types; an episodic emission, when a rupture disc pops or when a relief valve opens, and a continuous emission, when the valve does not reseat properly after the pressure is relieved. The latter case, in which the leak occurs because of improper mating of the sealing surfaces, is of more interest here.

Other types of valves can leak in several ways. An in-line valve, such as a block or control valve, can leak through the valve stem, bonnet, and flanges. An additional mode of leakage occurs for open ended valves, such as drain or sample valves. In addition to the sealing failures, leaks can occur in these valves when they are not completely closed, through either degradation of the valve or improper operation.

Although leaks from individual sources are relatively small, the total emissions from these sources can be quite significant because of the very large number of potential sources. For example, a model typical sized petroleum refinery of 15,900 cubic meter per day throughput with 10 processing units has an estimated 250 pump seals, 14 compressor seals, 25,000 valves, 1400 process drains, and 130 relief valves venting to atmosphere.[1] On the other hand, a model typical sized maleic anhydride manufacturing facility with a capacity of 22,700 Mg/yr, has an estimated 15 pump seals and 500 valves.[2]

Not all of the potential sources of VOC emissions will actually leak, however. Several studies have found that the majority of potential sources do not leak. Of the remainder, some leak a minor amount, while a few sources account for a large part of the total VOC emitted.[3,4,5,6,7,8] For example, in one of these studies 73 percent of the refinery valves tested had insignificant VOC emissions to the atmosphere. Twenty-five percent of the valves tested emitted up to 2.2 kilograms per day (kg/day), and accounted for one-fourth of the total emissions. The remaining two percent of the valves each emitted over 2.2 kg/day, and accounted for three-quarters of the total emissions.[9] Data for chemical plants are very limited. One study found that 34 percent of the pump seals leaked.[10] Since there are many potential leak sources which have widely varying leak rates, it is necessary to utilize leak detection methods to effectively locate these leaks. Once located, the leaking equipment can be repaired and emissions to atmosphere reduced.

LEAK DETECTION METHODS

Four methods for detection of volatile organic compound emissions from equipment leaks are presented here. Along with a description of the methods, the advantages and disadvantages of each approach are discussed, including relative leak detection effectiveness.

Complete Individual Component Survey

In a complete individual component survey each potential leak source is screened to determine if the component is leaking. A component is screened by using a portable VOC detection device to measure the VOC concentration at the surfaces where leakage could occur. The instrument probe should be moved along the surface, with emphasis on positioning the probe at the upwind and downwind side of the component. Some potential sources, such as with process drains, cooling towers, pressure relief devices, and open-ended pipes, have open exhaust areas to the atmosphere rather than a seal interface. For these sources, the probe should be placed at the centroid of this area as well as at upwind and downwind points. These surveys can be performed by two-man teams, one operating the instrument and the other recording results.

The major advantage of the complete individual component survey is that it should locate all significant equipment leaks. By checking each component individually, all leaks should be noted, and there should be no false indications of high concentrations where no leak is found. The major disadvantage of this method is that it has a relatively high manpower requirement. In a complete individual component survey of a refinery similar to the model 15,900 cubic meter per day refinery, two men performing the survey required a total of almost 1000 manhours.[11]

Unit Area Survey

A unit area survey entails measuring the ambient VOC concentration within a given distance, for example one meter, of all ground level equipment within a processing area. These measurements are performed with a portable VOC detection instrument utilizing a strip chart recorder. The instrument operator walks on both the upwind and downwind side of the equipment, noting on the chart record the location in the unit where any elevated VOC concentrations are detected. If an elevated VOC concentration is noted, the components in that area will have to be individually screened to locate the specific leaking component.

The major advantage of this method is that large leaks from all ground level sources can be quickly located. The manpower requirements for this method are much lower than those for the complete component check. Among the disadvantages of this method are (1) leaks from adjacent units can cause false leak indications, (2) high or intermittent winds (local meteorological conditions) can increase dispersion of VOC and cause large leaks to go undetected, and (3) additional effort is necessary to locate the specific leaking equipment.

Unit Boundary Survey

In a unit boundary survey the VOC concentration at the edges of each processing unit is monitored. Again, a portable VOC detection instrument and strip chart recorder are utilized to perform the measurements. When an elevated concentration is detected, the operator should note its location and the wind speed and direction on the strip chart record. As in the unit area survey the source of the elevated concentration will have to be determined by performing an individual component survey on the equipment in the area of the elevated concentration.

Unit boundary monitoring has the lowest manpower requirement of the first three leak detection methods. It can be used as a quick way to determine the presence of large leaks in a unit. However, unit boundary monitoring is highly sensitive to local meteorology. For example, a large leak may not be detected because of dispersion. On the other hand, high concentrations that are recorded may be the result of emissions from non-leak sources, such as downwash from a process vent. Further, an additional effort must be made to locate the leaking equipment once an elevated concentration is found.

Fixed Point Monitoring Systems

The basic concept of the fixed monitoring system is that equipment can be installed at specific sites within the process area to automatically monitor for leaks.

There are several approaches to leak detection with fixed-point monitors. These differ in the number and placement of the sample points, and the manner in which the sample is taken and analyzed. One approach is to place monitors near specific pieces of equipment, such as process pumps, compressors, and cooling towers. These monitors can sample either the VOC concentration or the operation of equipment, i.e. to monitor the pressure between double mechanical seals to indicate failure of either seal. These systems will tell the operator the location of the leaks that are detected. A second approach is to place the sample points in a grid pattern throughout the process area near the potential leak sources. When an elevated concentration is noted, the operator must perform in individual component survey on equipment in that area to locate the leaking component. In addition to these variations in the location of the sampling points, different types of instruments can be used. For example the monitoring system can consist of either continuous sampling and analysis, or an automatic sequential system where samples are collected and analyzed at a central location.

One advantage of the fixed-point monitor approach is that the location and type of sampling and analysis can be tailored to meet the specific requirements of individual plant sites. An additional advantage is the ability to sample for specific compounds by GC analysis. Fixed point monitoring systems have the highest capital cost and the lowest monitoring manpower requirement of the four methods. Further, the approach may still require the use of a portable VOC detection device to locate the leak, particularly if process area monitoring is used. This monitoring method is currently being used in several organic chemical manufacturing facilities, including ethylene oxide and vinyl chloride production.

SUMMARY

In this paper, four methods of leak detection have been discussed. It has been shown that, although a complete individual component survey has the highest manpower requirement, it will specifically locate all leaks. The other methods detect the presence of large leaks but usually an additional effort is required to locate the actual leaking equipment. For example, if an elevated concentration is found at a pump row during a unit area survey, all of the pump seals, valves, drains, etc., in that immediate vicinity must be individually sampled to locate the leak. A similar procedure is used to locate leaks when conducting a unit boundary survey or when using certain types of fixed point monitoring systems. This is illustrated in Figure 1. Timely repair of leaks found by these methods will reduce VOC emissions to the atmosphere.

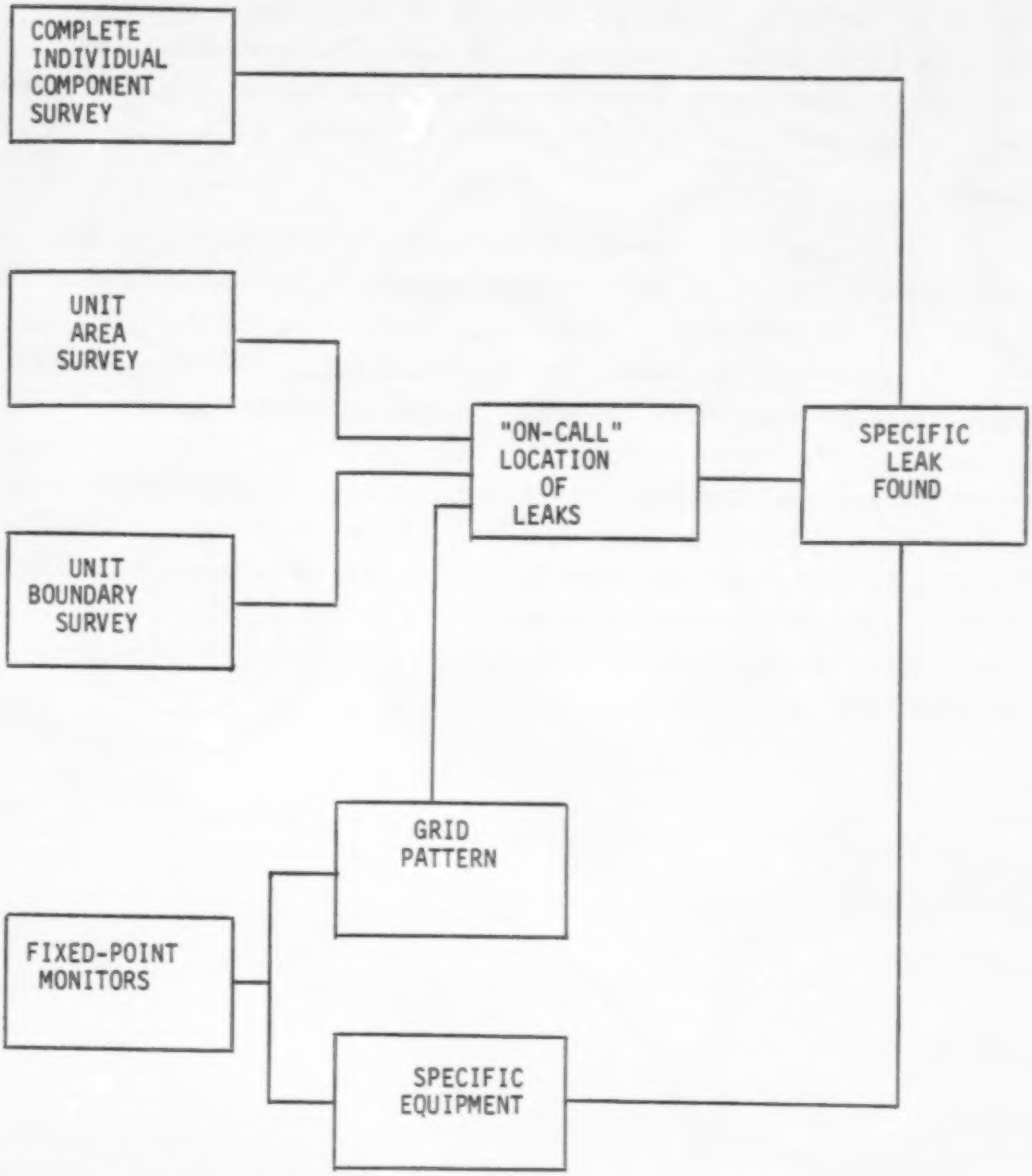
COMPLETE INDIVIDUAL COMPONENT SURVEY
UNIT AREA SURVEY
UNIT BOUNDARY SURVEY
"ON-CALL" LOCATION OF LEAKS
SPECIFIC LEAK FOUND
GRID PATTERN
FIXED-POINT MONITORS
SPECIFIC EQUIPMENT

FIGURE 1. ALTERNATIVE LEAK DETECTION METHODS

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QUESTIONS AND ANSWERS

Q. Herb Bruch - Have you looked at the size of the refinery units and determined costs, like a smaller refinery, say 30,000 bbl/day vs. one at 100,000 bbl/day?

A. - Costing what? The various methods?

Q. Herb Bruch - Monitoring fittings.

A. - The costs are a function of the number of sources and the frequency of monitoring. If they had the same degree of fractionation, a large crude unit would have the same number of sources as a smaller one, so the cost of monitoring them would be the same. I imagine the small refineries usually have less fractionation so you have less pumps and valves. Familiarity of the instrument operator with the area is important; so that you don't check steam valves, etc.

Q. - J. Daily - Is there a specific make of VOC unit that you use or is there a broad range?

A. - We use the Century Systems OVA-108.

Q. J. Daily - Is that the only thing you have tried?

A. - We have also tried the Bacharach TLV. When performing this type of monitoring, we are going from one piece of equipment to another as fast as possible, finding leak or no leak and moving on. We found the OVA superior because of the fast response time and a high pumping rate to clear the sample probe. The Bacharach operates on the hot-filament principle. Once it gets heavy hydrocarbon on it, it does not clear very quickly. You have to walk out of the unit. Once you find a large leak, your instrument is dead for about 10 minutes. With the OVA, a leak can put the fire out, but one can step back and re-light it very quickly. The OVA is instrinsically safe in hazardous areas.

Q. - Did you actually test this fixed point monitoring system?

A. - I've not performed tests on it myself. There have been some studies performed on fixed monitoring systems. Vinyl chloride plants in Region V have been inspected and reports have been issued on them as to their state of compliance. We are reviewing these reports, and we have test plans underway.

Q. - I think you had on your evaluation sheet a low labor cost for fixed point monitoring systems. If you use something of this nature and maintain it properly, labor is going to be higher than you expect.

A. - This is only monitoring labor that I have referred to on the chart. Fixed point monitoring systems will have a higher maintenance cost, as will maintaining the portable instruments. There are problems with these types of instruments that have been found in chemical plants.

STATE REGULATIONS FOR CONTROL OF REFINERY EMISSIONS

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ABSTRACT

This paper illustrates a state air pollution control philosophy and summarizes provisions of Texas' Regulations governing control of refinery emissions. Provisins of TACB Regulation VI "Control of Air Pollution by Permits for New Construction or Modification" are detailed as Texas' strongest control mechanism. Regulation V, "Control of Air Pollution by Volatile Carbon Compounds" is reviewed as having greatest impact on control of emissions from existing petroleum refineries, and as an example of effect current revisions will have on state policy and control philosophy. This discussion includes definitional changes, plans for and effect of implementing EPA's Applicable Control Techniques Guidelines, and difficulties found in designating geographical areas in which these controls will be applied.

Also presented are anticipated rule changes on fugitive emissions and current thinking on need for rule changes resulting from fuel conversion efforts.

RESUME

Hank Sievers is from the Texas Air Control Board. He has a B.S. and M.S. Degrees in Meteorology from Texas A&M; a B.S. in Electrical Engineering from the University of Texas and an M.S. in Environmental Health Engineering from University of Texas. He served in the service with the Air Force. He has been with the Texas Air Control Board for 5-1/2 years. Currently, he is Chief of the Control Programs Section, the Control Strategy Division.

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Henry E. Sievers

STATE REGULATIONS FOR CONTROL OF REFINERY EMISSIONS

As representatives from other states and territories here can attest, state air pollution regulatory agencies often find themselves in the role of balancing conflicting desires of EPA, citizens environmental groups, industry, local governments, and the public. This role is not always an easy one. Open communication and opportunity to share viewpoints helps. As a representative of Texas Air Control Board, I thank you for this opportunity to present a state viewpoint on control of refinery emissions.

I'm not here to "talk Texas." However, petroleum refining ranks third among our nation's industries and Texas' refining capacity is first in the country both in number of plants, 40, and barrels produced each day, about three and three-quarters million. Translated, this figure accounts for more than a quarter of the national total. For Texas, with respect to emissions, this production results in emissions accounting for approximately 21 percent of total point source emissions in the state, and 13 percent of total point and area sources. Obviously we have had to develop control strategies as have other states, to impact this significant percentage. Of the 38 states with oil refineries, half have refinery related controls on emissions of volatile organic compounds. In terms of capacity, these 19 states process about 83 percent of the national total. Development of policy at the state level, provisions of 1977 Amendments to the Clean Air Act and subsequent rules, regulations, and interpretative rulings of the Environmental Protection Agency have resulted in the emergence of issues--past, pending, and anticipated--that may be of interest to us all. I plan today to touch briefly on these issues and hopefully generate a forum for general discussion.

Since its inception in 1965, the Texas Air Control Board has sought to strike a reasonable balance among concerns for clean air, new industry, jobs, and a healthy economy. Our enabling legislation, the Texas Clean Air Act, mandates consideration be given to the character and degree of injury to, or interference with, health and physical property of the people; social and economic value of the source; location priority; and the technical practicability of reducing or eliminating emissions resulting from the source. Through the years we have developed a control philosophy designed to achieve our clean air goals without sacrificing industrial development or expansion. We have adopted eight regulations to conduct our air control activities. Seven of them apply to existing sources and are organized by type of emissions.

Regulation VI, Control of Air Pollution by Issuance of Permits for New Construction or Modification, is our primary control mechanism for new sources. Permitting new sources is probably our most effective control measure. It both allows economic application of more stringent controls than feasibly can be applied to existing sources, and is easier to enforce because permit conditions are tailored to a specific source. Legal authority for this regulation was given to the Board in 1971 Amendments to the Texas Clean Air Act. It requires that any person who plans to construct any new facility or to engage in the modification of any existing facility which may emit air contaminants must obtain a construction permit from Texas Air Control Board prior to beginning work on the facility. If a permit to construct is issued, an operating permit must be applied for within 60 days after the facility has begun operating, in most cases.

In order to be granted a permit to construct and to operate, the owner or operator of a proposed facility must demonstrate compliance with all Rules and Regulations of the Texas Air Control Board and the intent of the Texas Clean Air

Act. He or she must also demonstrate that the proposed facility will not prevent maintenance or attainment of any applicable ambient air quality standard nor cause significant deterioration of existing ambient air quality in the area. The application also must contain demonstration of proper consideration of land use, utilization of best available control technology, and that technical practicability and economic reasonableness of reducing or eliminating emissions resulting from the facility was considered. The proposed facility also must meet, at minimum, requirements of any applicable new source performance standards or emission standards promulgated by EPA pursuant to authority granted under Sections 111 and 112 of the federal Clean Air Act, as amended.

In January of this year, the Texas Air Control Board reluctantly voted to adopt the controversial EPA offset policy, providing that new sources offset projected emissions. Despite our serious reservations, we have incorporated this policy into Regulation VI which deals with permits. Essentially we are enforcing the requirements of EPA's interpretative ruling on 40 CFR 51.18. When the proposed facility is in a nonattainment area for national ambient air quality standards, which with one exception in Texas are for photochemical oxidants and TSP, and if emissions potential for these pollutants is 100 tons per year or greater, the applicant must attain the lowest achievable emission rate. If allowable emissions of the proposed facility, determined as the maximum permissible rate after controls are applied, still are equal to or in excess of 100 tons, then the applicant must propose offset measures which represent greater than a one-to-one ratio of decreased over increased emissions. A statement certifying that all existing facilities of this owner, if any, in the applicable AQCR are in compliance with all applicable TACB Rules and Regulations or in compliance with an approved schedule also must be provided. This implementation procedure has revealed some ambiguities in the Clean Air Act and EPA's interpretative ruling. We have applied our own interpretation to some of them, making assumptions we believe maintain the integrity of the intent of both.

One example is that application of offset is limited to sources with potential of 100 tons of emissions per year. It may be argued that setting this limitation exempts facilities of a size that, taken together, could represent figures well over 100 tons and significant percentages of emissions in a given area. Also, abuse of the intent of providing a net air quality benefit through offset could incur if industry expansion were designed for growth through increment--through establishing separate facilities none of which alone would have 100 tons or greater annual allowable emissions. Such a system abuses both industry and ambient air quality. For these reasons we apply the 100-ton limitation to combined emissions allowable for previously permitted facilities and proposed facilities at a given source location or site. A typical permit falling under the offset policy carries with it 30-to-40 provisions designed to document and enforce these and other requirements of new source review.

The potential differential between actual and allowable emissions represents another issue we feel needs clarification. As stated, the interpretative ruling requires that reductions achieved by offsets result in a net reduction of total allowable emissions from existing sources. Since actual emissions can be, and very often are, considerably below allowed emissions, literal application of this concept could result in manipulation of emissions reductions that literally would be acceptable, but which could in practice increase actual emissions in the affected area. For this reason, our permits section uses actual emissions in calculating and approving offset credits.

A third issue we believe needs EPA clarification is prohibition of "banking" offset credits to new sources. This policy discourages voluntary application of control more stringent than applicable state regulations. It also discourages cost effective growth since the source owner could, if banking were allowed, expand when and where it would be to his economic advantage to do so, without losing offset credits. If banking were allowed on a per company or per site basis, voluntary reduction of emissions of sources that are not controlled by state regulations also would be encouraged. We feel some ambiguity in this policy exists since states and communities are permitted to commit to emissions reductions when growth is desired. This procedure could, in effect, be construed as establishment of a state- or community-operated bank.

Our permits division has been involved in lengthy consultation with EPA over these issues, and we hope for EPA clarification in the near future.

Thus far I have presented a summary of issues confronting us under permitting of new sources. Controls on existing sources also have significant impact on petroleum refineries. Volatile Organic Compounds in Texas are controlled by TACB Regulation V. I plan to focus on this regulation since petroleum refineries are a significant source of VOC and represent a potential emission problem by virtue of the large quantities of petroleum refined and the intricacy of the refining process. Also, refineries tend to be located in areas where the oxidant national ambient air quality standards are likely to be exceeded. In Texas, for example, the petroleum refining industry is concentrated on the gulf coast. Estimates of nonmethane hydrocarbon emissions in the Houston-Galveston SMSA total about 47,141 tons annually. This figure represents 23 percent of total nonmethane hydrocarbon emissions in the area. Ozone measurements there have been recorded at .155 to .261 ppm in the three nonattainment counties falling in this seven-county standard metropolitan statistical area.

Regulation V, Control of Air Pollution from Volatile Carbon Compounds, covers storage of volatile carbon compounds, crude oil, or condensate; loading and unloading facilities; filling of gasoline storage vessels; water separation; and waste gas disposal. Current efforts are directed at substantial revision of this regulation. Revisions underway are to enhance clarity of existing control measures, to modify areas regulated, and to incorporate technology outlined in the first eleven _Applicable Control Techniques Guidelines_ issued by EPA's Office of Air Quality Planning and Standards.

Regulation V's title will be changed to "Control of Air Pollution from Volatile Organic Compounds" for consistency with EPA nomenclature. Second, to insure the scope of the regulation is clear, VOC is being defined as any compound of carbon (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate) that has a vapor pressure greater than 0.1 mm of Hg at standard conditions. Currently we define volatile carbon compounds as compounds with vapor pressure of 1.5 psia or greater and control them at those levels. This definitional change will clarify the compounds controlled and still will apply only to VOC with 1.5 psia or greater. We also are developing a new Regulation IX for control of carbon monoxide, since it no longer will be covered by Regulation V.

Applicable Control Techniques Guidelines which pertain to refineries are _Control of Refinery Vacuum Producing Systems_, _Wastewater Separators_, and _Process Unit Turnarounds_, issued in October, 1977; and _Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks_, issued in December, 1977.

With slight differences in emphasis and wording, our existing Regulation V covers technologies outlined in these documents except for process unit turnarounds. This process currently is being incorporated. Application of technologies in Regulation V have accounted for fairly significant reductions of uncontrolled refinery emissions in the state, about 30 percent, with 18 percent attributed to controls on wastewater separators, 6 percent from vacuum jets, and 6 percent from fluid catalytic cracking units (FCCU). Estimates are that, in the Houston area, these controls have resulted in a 50 percent reduction over a 4-year period. Application of RACT for process unit turnaround is expected to account for an additional 10-15 percent reduction of uncontrolled emissions statewide.

As we make revisions to this regulation, and in development of our current SIP, designation of areas or counties to be covered by these controls is a very real problem.

Parts of current Regulation V apply to 19 Texas counties which account for 90 percent of total emissions in the state. These counties were selected prior to state and EPA designation of nonattainment areas for NAAQS. Last July, EPA promulgated regulations to expand areas covered for certain controls, including storage of crude oil. These areas included counties in close proximity to those included in nonattainment areas for the photochemical oxidant standard. At the state level, then, we are found with (1) Our original list of counties falling under Regulation V, (2) a disimiliar EPA-promulgated list for which certain rules apply, and (3) designated nonattainment areas. Obviously there exists a problem on geographical application of these controls. Applying Regulation V, as modified, to any county included in these designations would expand the list of counties covered and generally impose more stringent rules to a greater number of existing sources. Petroleum refineries operating in some attainment areas would therefore be forced to comply with the additional controls required for nonattainment areas. Current thinking is to include nonattainment counties only, although a firm decision has not been made.

Thus far I have summarized changes we presently are incorporating. One change that was considered, but not adopted, warrants some discussion.

As you are aware, last May EPA released a draft document on fugitive emissions, _Control of Hydrocarbons from Miscellaneous Refinery Sources_ along with control technology outlined in _Air Pollution Control Technology Available to 26 Sources of Volatile Organic Compounds_.

During negotiations between EPA and TACB on adoption of the offset policy last fall, TACB applied for a waiver. Provisions of our waiver application included agreement to modify Regulation V to incorporate RACT as defined by the extremely stringent provisions of these documents.

In Texas, proposed regulations or proposed regulation changes are discussed among TACB staff, and with interested or affected parties including regional offices and groups representing industry, local governments, protection of the environment, and the public interest. Public hearings are held, comments voiced, and changes incorporated before adoption.

During these processes, industrial response to the proposed fugitive rule change was overwhelmingly negative. Exxon Corporation, for example, estimated cost of incorporating these changes in one refinery at two and one-half million dollars. When it became evident that TACB would not receive a waiver from offset, adoption of this entire set of proposed rules was delayed. We do not intend to impose such restrictive rules on industry unless publication of final guidelines, expected in June, requires us to do so. Application of additional industrial controls takes away opportunities by industry to offset emissions, in turn limiting industrial growth. Such limits we consider a negative factor in the general welfare of our state, an inequitable tradeoff since estimates are these controls would result in a reduction of 34,000 tons annually, or only 6 percent of total uncontrolled refinery emissions.

Several studies on fugitive emission data were conducted in Texas last fall with the intent of obtaining additional data prior to finalization of EPA guidelines. One, instigated by Texas Chemical Council, a chemical industrial trade association, was conducted by Exxon Chemical. As part of the study, fugitive sources--valves, pumps, compressors, flanges, etcetera--were measured for losses. Preliminary findings indicated that fugitive losses through valves may be as much as 70 percent less than EPA estimates indicate. Therefore, emissions factors may be much lower than EPA figures, even though several vents were found to have losses greater than expected.

Another study was conducted at Amoco/Texas City Refinery by TACB staff and EPA to cover fugitive emissions from standpoints of sampling, leak detection, and control technology.

Informal estimates were that proposed fugitive emission controls would require addition of an estimated 45 persons, an increase of 7 to 8 percent of total operators, resulting in increase of about 1.4 million dollars for the 23 process units involved. Final results of both studies are pending. Joint committees have been set up with Texas Air Control Board and the Texas Chemical Council to review final results of these studies, when released, and to coordinate activities in implementing EPA guidelines for fugitive emissions, when published.

Issues I have outlined thus far occupy us today. In terms of future developments, probably the most far reaching change facing Texas, especially the Texas Gulf Coast, is boiler fuel conversion. We expect most petroleum refineries to convert to fuel oil as natural gas resources dwindle. The primary impact will be increase in emissions of sulfur dioxide and particulate matter, which may require modification of TACB Regulations I and II. Current thinking is to control the sulfur content in allowable fuel oils, although limited availability and cost pose problems for such an approach. At present we are researching probable effects of fuel conversion by applying dispersion modeling techniques.

In summary, I think it is fair to say Texas Air Control Board has taken, and continues to take all necessary steps to protect public health and welfare according to the legislative mandate of the Texas Clean Air Act. In establishing regulations and in proposing rule changes, we take into account the very real considerations of the comprehensive impact our actions will have in Texas. We believe that a strong industrial and economic base is as essential to general welfare as is clean air, and that pollution control agencies must take this fact into account. We also constantly review our regulations in an ongoing process dependent on newest conclusions derived from research and analysis of chemical reactions and state-of-the-art technology. We cannot, as it were, operate in a vacuum. To this end we must all continue to work--EPA in consideration of technical feasibility and economic reasonableness; state air pollution agencies in enforcing air control regulations with an eye toward balance; and local governments and industry in pursuing clean air goals with good faith efforts.

Thank you for your attention. I welcome and solicit comments or questions.

QUESTIONS AND ANSWERS

Q. - Can you tell us a little bit more about how you expect the SIP revision process to go, specifically, do you believe that Texas will complete its revision by the end of this year so as to avoid the construction ban in the middle of 1979?

A. - Yes indeed. We are currently revising Regulation V to incorporate these RACT. We hope to have this done shortly and to go to public hearings with it--probably in June. We also have been working with our local governments and planning agencies in developing a transportation planning process which, as we understand it, is all that is necessary for the SIP revision. This, we hope, will be done by the end of the year. We are having several workshops and meetings throughout the state which will take care of the consultation requirements for the plan. We will also have public hearings at the end of the year which will incorporate all of our control strategies and we'll be able to submit a plan by the first of January.

Q. - You said you needed a 70% rollback of reductions of overall hydrocarbons being considered, also organics, is that by rollback or is that with modeling?

A. - That was using rollback. We also used the EKMA model, and in all cases the reductions required there are higher than by using the rollback methods. So we chose, as EPA says we can, the rollback method to determine the amount of reduction.

Q. - Do you think 70% reduction overall is possible?

A. - Yes, it is possible. No, I don't think it is practical. I think we are hoping that by the time everything is laid before the public and we show the type of controls that would be necessary to meet this standard, that possibly the laws will be changed.

Q. - How much of that 70% was from stationary sources and how much from mobile sources?

A. - We can get this anywhere we want to. EPA doesn't say how you have to get this reduction. What we have done is made a gross estimate of how much reduction will result from the changes to our Regulation V on existing sources and from the changes in mobile sources due to the new car standards, then add in some for permits which have already been issued before the offset requirement. In any case, it looks like we are going to get about 11% from fixed sources, probably about 24% from mobile sources in that area by 1985, which still leaves about 43%.

Q. - Are inspection and maintenance in that 24%?

A. - No, we haven't had time to evaluate that. We are probably going to be forced to have inspection and maintenance. We are not quite sure what method. The problem is the legislature has to meet to approve it, so we are not sure of the 24%.

Q. - On your 11% on the fixed, do you have any idea of how much of that would be from fugitive sources?

A. - Actually that is not including fugitive sources at all, because this is just from the existing guidelines that we have.

Q. Is TACB continuing the offset policy as part of the SIP revision?

A. - I don't know that we have any alternative. We've got to allow for growth somehow and this is one way of doing it. The other way, of course, is to impose additional restrictions which essentially will allow some growth.

Q. - Would you say that the control plan would be a combination of the two?

A. - We will, if we can, build in enough decreases to account for some growth, but you see from these numbers that we aren't quite sure how we are going to do that.

Q. - From a cost-effectiveness standpoint, is there any consideration being given to the photochemical reactivity of pollutants or is it blanket reductions?

A. - No, we are following EPA guidelines that say essentially everything except methane and ethane and those two other compounds are photochemically reactive sooner or later. If not in the immediate area, then sometime after they are transported to another area. So we are essentially on a non-methane basis.

Q. - Do you have any feel for when we will get to see a bound copy of the revised Regulation V?

A. - Hopefully any day now. Probably it will be a couple weeks and we will have something ready to send out for another review. We do, of course, intend to have a fairly complete review of this regulation, and, all of our other control strategies. So if anyone wants a copy of it, let us know and we welcome your input and criticism.

INSPECTION AND MONITORING CONCEPTS FOR REFINERY FUGITIVE EMISSIONS

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ABSTRACT

A discussion on the concepts to be considered in framing regulations to control refinery fugitive emissions from valves. Those concepts involve the inspection, monitoring, reporting, and enforcement segments of any proposed regulation, and were in part developed through testing at a refinery in Carson, California.

RESUME

John Nakagama received his Bachelor's degree in Chemical Engineering in 1954 from the University of Utah and joined Atlantic Richfield immediately after graduation. He spent 20 years in refinery tech service, 17 years as a supervisor of various process units in a refinery. The last two years John has been involved in environmental work for ARCO. He is currently Director of Environmental Affairs for the Western area.

John Nakagama

INSPECTION AND MONITORING CONCEPTS FOR REFINERY FUGITIVE EMISSIONS

INTRODUCTION

Refinery fugitive emissions as evidenced not only by this workshop but by recent events in California and Texas have obviously become a major concern of the regulatory agencies. Since the last concerted effort to address this subject was made in 1957,(1) this might appear to the critical observer that the renewed concern is a belated one that has been long overdue. If in fact hydrocarbons have been polluting the air we breathe, why has not something been done about it? My response is that this renewed concern is in fact more indicative of the extent to which regulatory review has come. Consider that of the volatile organic emissions from stationary sources, refineries contribute 2.8% of the total(2) and of that fugitive emissions represent some portion. Even based on conservative factors the fugitive emissions are probably less than 1% of the total from stationary sources. Consider also that by the definition of fugitive emissions we encompass a wide range of equipment and the very massive number of items which make practical measurement and control extremely difficult.

Nevertheless, we are not here today to defend any "belated" concern or bemoan the difficulty of the solution, but in fact to solve the problem. We are as a company concerned about reducing fugitive emissions and providing input to regulations that cost effectively accomplishes the same.

A RESTATEMENT OF THE PROBLEM

In this discussion, I would like to limit the problem as one to develop an inspection and monitoring program for the reduction of fugitive emissions from valves. There are several reasons for this. One of course is in the interest of time. But the major reason is that the definition of fugitive emissions encompass such a wide variety of sources that the quantity of emissions from each type are probably totally different. And if not, the control methods should be. For instance, in the case of flanges per se the past and more recent tests have shown that emissions from flanges are essentially negligible and with the sheer magnitude of the number of flanges there is no practical need for specific regulatory control.

In light of the fact that EPA has now published a guideline series on vacuum producing systems, wastewater separators and process unit turnarounds, this delineation is not totally inconsistent with their own approach. I would, however, urge that both industry and the regulatory agencies develop a more reliable data base for both quantity of emission and cost of control in order that: (1) Industry would have the time and opportunity to provide some meaningful input on each specific proposal. (2) The final regulations will be developed to control emissions in the most cost beneficial mode conserving not only the agency's and industry's limited resources, but ultimately that of the consumer's.

THE DATA BASE

Regarding the establishment of a more reliable data base, it would be nice to argue for the completion of the present EPA/Radian study before any further action is taken. In light of the mandates of the Clean Air Act Amendments and recent actions by local regulatory agencies, I doubt that we have the luxury of that option. Regulations, if not adopted, will at least be proposed and industry will have to respond. With this in mind we have undertaken two projects at our Watson Refinery at Carson, California.

The first project involved a crude distillation unit with a rated capacity of 38,000 B/D. The objective of the study was to assess the costs that would be incurred for the inspection of all valves and fittings for the detection of any leaks, large or small. In all 11,414 leak sources, of which 1,415 were valves, were identified and tested. In all 38 leaks were discovered, 17 of which were valves and 21 fittings. Of those leaks, 16 valves and 15 fittings were repaired without a unit shutdown. The costs incurred for this unit inspection was then pro-rated for the entire refinery. If the inspections were conducted on a monthly basis as initially proposed in the EPA guideline, the cost, exclusive of our present maintenance budget, would run $1,500,000 per year. Obviously, if the frequency of inspections are reduced, so are the costs. But the more pertinent question to be answered is, "what frequency of inspection is needed?" That question can be partially answered by the fact that when the California Air Resqurces Board Inspection Team re-inspected that unit eight months later, with only the normal maintenance procedures conducted at that unit in the interim, no leaks were detected.

But in order to provide additional data to answer the question of the frequency needed, we have initiated a second project. At our LPG, storage and transfer facility each component will be inspected for leaks. The leaks will be repaired and each component will be inspected at fixed intervals of time to determine at what point inspection would be warranted. If the components once repaired do not leak for a year or more, that's fine, but I am afraid that any correlation developed will not be in time to influence any rule making. But then again perhaps the effort will. If is on this note of lack of data and impending regulations that I offer the following concepts.

1. Limit the inspection to high probability areas.

   At the outset limit the inspection to those types of units that are the most probable to have leaks and whose emissions would be the most reactive and/or toxic. Granted all the data are not available and valves in any unit probably leak to some degree, but let's make the attempt. Units that I would consider include: aromatic, ethylene, cracking unit gas plants, alkylation and LPG units. Leave out crude-vacuum, treating, heavy oil processing, fuel gas systems and even reforming and hydrocracking units. The latter units operate with a high hydrogen partial pressure and leak mostly hydrogen that has its own automatic detection device, auto-ignition, and those leaks get immediate attention for safety reason.

Whether to include one or more or even all the units depends on the proposed regulation. If the frequency of inspection proposed is high then limit the number of units to be controlled to obtain a good data base and amend the regulation accordingly. If the frequency is practical and cost effective, then include more units.

2. Inspection Frequency and Method.

Given that the units selected are those high probablity units previously mentioned, I would suggest that a reasonable frequency for the inspection for each valve should occur just prior to a scheduled turnaround. During this inspection, leaks that would have required partial shutdown of the unit with its resultant emissions can be repaired or replaced during the shutdown minimizing the overall emissions. Leaks that might have developed between shutdowns and found and repaired could be taken care of by a walk-through monitoring inspection.

The method for detecting valve leaks should be left up to the operator. The major point is to locate and repair, not quantify, the leak. In some instances, a hydrocarbon detector would be preferred, in others a soap test or visual inspection would suffice. A hydrocarbon detector would require calibration and specialized training. Delays and arguments concerning various craft jurisdictions would only hamper the effort. In those instances, the soap test or visual inspection brings the unit operator into the process of effectiving an improvement in his unit, increasing his awareness and morale and ultimately increasing the efficiency and effectiveness of the program.

3. Reporting and Enforcement

The most difficult segment of any proposed regulation to control fugitive emissions is in the reporting and enforcement. If the reporting is to be a self-enforcement mechanism coupled with severe penalties, then the costs for reducing these emissions becomes inordinately high and the whole program is not practical. Consider that in our Watson Refinery there are more than 120,000 valves. If it were necessary to number, date, record and file all of the data on these valves to ensure that no violations occurred, the cost of the paper work would soon outweigh the cost of locating and repairing the leak. This sort of effort would be analogous to requiring the motorist to maintain a file on all possible leak sources on his automobile. On the other hand, if the effort is too lax, then emissions reductions may very likely not occur. Somewhere in the middle ground is the solution.

Since the strict reporting and enforcement approach is intended to ferret out the indifferent operator, then perhaps another approach would accomplish that. I would suggest that this could be accomplished by the enforcement agency reviewing the maintenance policies and practices that are in fact in force at the facility. Some of things to be considered should include: (1) procedures for testing of new and re-serviced valves,(2) selection of the proper lubricant and gasket materials, (3) on-site inspection of the check lists and tagging system for leaking valves. (4) maintenance procedures for assignment of repairs, (5) unit operator training practices. This review coupled with the authority of the enforcement inspector to cite the facility for violations under presently existing regulations should accomplish the goal of reducing emissions.

SUMMARY

Considering then the probability that industry will soon be faced with addressing proposed regulations on the control of fugitive emissions, I would like to re-state some of the concepts that should be considered in framing those regulations.

1. In light of the inadequate data limit the scope of the regulation to high probability areas.
2. Inspection of each component should be made just prior to the scheduled turnaround.
3. The method of inspection should be left up to the facility.
4. The reporting should be limited and supplemented by review of maintenance policies and practices of the facility.
5. The enforcement can be accomplished through existing regulations.

If in fact these concepts are applied, I am sure that an effective reduction in fugitive emissions can be accomplished within the framework of an efficient utilization of resources.

REFERENCES

1. "Joint District, Federal and State Project for the Evaluation of Refinery Emissions", Los Angeles Air Pollution Control District. 1957.

2. Letter from E. P. Crockett, API, to R. T. Walsh, U.S. EPA, July 18, 1977.

QUESTIONS AND ANSWERS

Comment - I think you have made a lot of practical suggestions. On the schedule for inspection valves, I think that this depends very much on the type of valve, for instance, if you have a lubricated plug valve, every time you turn the valve it should be greased. Secondly, if you have a packed valve where the stem is rising and it's a valve which cycles often, it will require frequent maintenance.

We make some valves for Universal Oil Products for their HF process. They have a green paint and if there is a leak it turns blue. I think if some investigation were made of using this paint, valves that are susceptible to leakage, particularly cold devices, would tend to indicate these leaks automatically; tagging could be avoided. Where you have fittings that are hot, you are getting a heat leak when you get a vapor leak. If you have a sensitive heat detection device, such as temp sticks, it would tend to identify the point where you had leaks. I particularly think this idea of paint or some sort of device which changes color to show susceptibility or chemical reaction with the leakage is a viable method of detecting leaks rather than using detection devices that are so sophisticated and so refined that you may pick up background contamination rather than the valve leak itself.

Comment - I agree with a lot of the concepts and especially the comments about record keeping. Having been a Control Officer myself, I get sick and tired of spending hours talking about nothing and stacks of paper and statistics which nobody believes anyway. But you have got to document them. I cannot go along with soap bubble tests, however.

P. Harrison - The problem with the detection on a particular interface is the fact if you don't happen to put soap on that particular point, then you don't even know it is there, let alone counting bubbles. The other thing I want to leave with you is the worst leaks, the majority of the worst leaks you see, are a matter of accessibility. So there are places where people don't like to go or can't go conveniently and things like that. I know darn well unless you have an instrument method you won't find them. There are leaks other places too, but I am talking about some of the real bad ones right now.

Comment - F. G. Mesich, Radian - We disagree with that statement.

J. Nakagama - I am glad you said that.

Atly Jefcoat - I think John has done an admirable job of presenting some logical approaches. This is the whole purpose of having these symposium workshops--to have an exchange of ideas. These issues and questions that have been brought up are ideal for the workshops this afternoon.

API EMISSION MEASUREMENT PROGRAMS

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ABSTRACT

The organization and responsibilities of the Committee on Evaporation Loss Measurement (CELM) are described within the framework of the API's environmental and measurement objectives. The CELM's 12 hydrocarbon evaporation loss bulletins, published during the period 1957-1969, are widely used by industry and government. However, due to advancements in equipment design and changes in operating procedures, the bulletins have been shown to generally overstate emission levels, and must be updated to assure proper use in the current regulatory climate.

The paper is part of a series of continuing status reports to industry and government on the CELM's updating efforts.

RESUME

Mr. Joseph Zabaga is an Associate Engineer with Mobil Research and Development Corporation in Princeton, New Jersey. His duties include responsibility for the technical aspects of hydrocarbon loss control. He is currently Chairman of the API Committee on Evaporation Loss Measurements. He is also a member of the API Advisory Panel to EPA for the refinery study that we currently have going. He is a member of APCA. CELM is now revising all of the evaporation loss forces on which hydrocarbon emission factors are based.

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J. G. Zabaga

API EMISSION MEASUREMENT PROGRAMS

INTRODUCTION

In addition to studies of hydrocarbon losses from fugitive sources, there are a number of other programs underway to quantify evaporation losses from petroleum handling equipment. The purpose of this paper is to present an overview of ongoing studies and the proposed time frame for completion of the general revision of hydrocarbon emission factor bulletins.

As most of you know, evaporation loss data from API bulletins has been used by regulatory agencies to develop hydrocarbon emission factors. However, publication of the bulletins preceded the Clean Air Act Amendments of 1970, and it has become quite clear that both industry and regulators need updated emissions data to properly respond to the Act.

This paper is part of a continuing series of reports to industry and government on the status of new measurement programs. Much of the new work is being done by the API's Committee on Evaporation Loss Measurement or CELM, whose activities I would like to describe.

Figure 1 shows the organizational structure of the API. There are a number of technically oriented departments, one of which is Non-Departmental/Industry Affairs. Within that department, as shown in Figure 2, is the Committee on Petroleum Measurement (COPM) a free-standing API committee. Titles of the standing committees briefly describe the scope of the Committee's responsibilities. In general, this is the establishment of standards for measurements of all types of petroleum products throughout the industry, including production, refining, distribution and marketing activities.

The CELM is one of COPM's standing committees. CELM deals only with the measurement of evaporation loss, which is quite different from the finite measurement responsibilities of other COPM committees in developing standards for inventory control or custody transfer.

Figure 3 shows the publications of the CELM that were developed over a 12-year period from 1957-1969. These bulletins were the first industry-published data on quantifying evaporation loss of hydrocarbon liquids, and they have been widely accepted. To this day they remain, or are the basis for, virtually all data sources dealing with hydrocarbon evaporation loss. EPA's AP-42 "Compilation of Air Pollutant Control Factors," has emission factors derived from the bulletins.

It is important to realize that all of the bulletins were published prior to the U.S. Clean Air Act and do not necessarily comprehend the accuracy levels required by the Act. The publications were originally developed to enable oil company operating divisions to prepare cost benefit studies for evaluation of alternative conservation techniques. When the data and estimating methods became one of the tools used by regulators for control strategies, it became necessary to review the content of all of the bulletins for suitability in this new application. The CELM is the working committee primarily responsible for that review.

Figure 4 shows the present organization of CELM. Figure 5 is a pictorial view of the equipment involved within each subcommittee's responsibility. The four groups are staffed by 33 members, 24 from oil companies and 9 from supplier companies. Note that these activities do not include hydrocarbon loss evaluations from fugitive or other point sources. Responsibility for fugitive loss determinations fall to the API environmental committee concerned broadly with stationary source emissions.

Also omitted from the figure, but implicit throughout this presentation, is any mention of several recent studies conducted by the Western Oil and Gas Association (WOGA), and the Chicago Bridge and Iron/Standard Oil of Ohio (CBI/SOHIO) floating roof project.

Referring to Figure 5, the petroleum liquids of concern to CELM, and the basic equipment and handling characteristics are as follows:

1. Marine vessels -- ships and barges -- which transport crude oils and all types of finished product. The depth of the loaded compartment and its preloading condition are major factors affecting evaporation loss as described later.

2. Open top floating-roof tanks have been in use since 1880 and in their present form since 1923. The concept is to curtail evaporation by floating a disc, the movable roof, in the liquid. Under certain conditions, some emissions result from the perimeter sealing ring area. Floating-roof tanks are usually used for liquids with storage vapor pressures between about 1.5 to about 11 psia, i.e., motor and aviation gasolines, and some crude oils.

3. Internal floating covers are a logical combination of open top and fixed-roof tanks, providing weather protection to the roof and contents, and evaporation control by use of a floating deck. Liquids generally stored are the same as in open top floating-roof tanks.

4. Fixed-roof tanks have been used for many years to store all types of petroleum. Recognition by industry that product could be conserved by use of one of the floating-roof systems, and later, regulations to limit use to finished product with less than 1.5 psia storage vapor pressure, have generally restricted use of fixed-roof tanks to distillates, residuals and some crude oils.

5. Tank truck and tank car considerations are confined primarily to motor gasolines. A small amount of other finished product and crude oil are also transported by these means. The method of loading and the vapor pressure are apparently the factors most affecting evaporation loss.

MARINE TERMINAL EMISSIONS

In 1976, CELM updated Bulletin 2514A, Hydrocarbon Emissions from Marine Vessel Loading of Gasolines. A small but important point in the bulletin title is the use of the term emissions, the first such use in an API evaporation loss document. This recognizes regulatory agency need for the emission factor format. Previously CELM was concerned only with an annual determination of the volume decrease caused by the change of hydrocarbon liquid to hydrocarbon vapor, which was defined as evaporation loss. This volume decrease was usually expressed in barrels per year and has traditionally been used by the industry for inventory control. Future API bulletins will include both emission and evaporation loss factors.

Figure 6 shows a summary of emission factors from 83 tests performed by four companies loading motor gasoline into ships and barges. These factors average about 40 percent of previously published data. The format also suggests the parameters that dominate the evaporation phenomena, depth of the loaded compartment and the hydrocarbon level present in the vessel on arrival at dockside. For any specific marine terminal the percentage of vessel compartments that annually arrive clean (i.e. low preloading concentration) or dirty (high concentration), can be determined by analysis of ships logs and terminal records. With this information the factors in Figure 6 can be adjusted with confidence to predict emission levels when loading motor gasolines.

Other factors are still required for loading crude oils and for emissions resulting from water ballasting of vessels after unloading either gasoline or crude.

Late last year the Western Oil and Gas Association (WOGA) completed a test program on loading California crudes. The program was specific to one California county and while much data was acquired, no predictive model was developed. However, eight oil companies, acting in response to an EPA 114A letter, have undertaken a coordinated program to develop new data on ballasting emissions, plus any information necessary to fill gaps in the previously described API and WOGA studies. Correlation of all of these efforts should provide the data base necessary for publication of new, comprehensive marine terminal emission factors late this year.

FLOATING ROOF TANKS

Emissions from floating-roof tanks have been under intensive investigation since 1976. While much of the data in the original API Bulletin (2517) was about 40 years old, the relatively slow evaporation rate from floating-roof tank seals and the difficulty in measuring the evaporation loss generally frustrated any new in-depth studies.

Figure 7 depicts a floating-roof tank and the perimeter seal area through which losses occur. The amount of evaporation occurring in a reasonable amount of time, say several months with the tank dormant, is too small to detect reliably with conventional measuring techniques.

Two new testing methods have been used in an attempt to overcome this problem. As shown in the figure, a field tank with product in it can be taken out of active service and permitted to weather. Separate testing has established that any evaporation due to tank wall wetting as the roof descends in normal operation is insignificant. Therefore, any emissions are those that result from loss of lighter gasoline components through the seal area. Further, tests have also shown that natural convective mixing maintains a homogeneous liquid in the tank. This establishes the format for one test approach. Periodic samples are taken and the density of the bulk liquid remaining is determined with an extremely precise density meter. Sensitivity is required, in grams per millilitre, to five decimal places. Establishing a time rate of density increase (increae due to loss of the lighter components) permits calculation of decrease in bulk volume.

A test program, using the density change method and involving 13 gasoline tanks, was completed in 1977 by WOGA. Average evaporation loss was about half of previously published values.

A second test program, also completed last year, was conducted by CBI/SOHIO. Here a 20 foot covered pilot tank, designed to simulate climatic and product variables, was used to capture and account for all hydrocarbon losses. Being capable of isolating individual variables, the study program developed a clearer understanding of the significance of the parameters affecting evaporation. Wind in particular was determined to play a dominant role in the evaporation process. The test program was designed for a specific client's application, and within that framework -- the latest in tank and seal technology for storage of crude oil -- indicates emission levels at about 10 to 20 percent of previously published values.

Neither of these programs can be extrapolated to a data base adequate to provide an emission predicting method for all types of floating-roof tanks in all geographical and service conditions. Therefore, CELM has developed a program to complement, correlate and conclude the two efforts just described and to develop new Bulletins 2517, "Evaporation Loss From Floating-Roof Tanks," and 2519, "Use of Internal Floating Covers and Covered Floating Roofs to Reduce Evaporation Loss," applicable to any open top or covered floating-roof tank. The CELM program combines density change and pilot tank techniques.

Phase I of the program is complete. It includes correlation of volume change determined by the density meter with vapor measurements of pilot tank losses, plus development of very specific field and laboratory testing techniques. Phase II of the program has recently been awarded to Radian Corporation. This work involves field testing with the density meter to develop scale up factors for the pilot tank measurements, which can then be used, with appropriate operating variables, to develop the necessary data base for a comprehensive understanding of floating-roof emissions.

Completion of all work necessary to rewrite the API bulletins is expected in 1979.

FIXED-ROOF TANKS

Current correlations for fixed-roof tanks are confined to products with a vapor pressure greater than two psia, and due to a limited data base, to tanks with diameters less than about 150 feet. Therefore, some crude oils, residuals and distillates stored in larger modern tanks are excluded. It is desirable to establish emission levels for these products.

Last year WOGA completed a 46-tank test program on crude and distillate liquids that provided some new data on emissions. The study demonstrated the apparent significance of the way a tank is operated, e.g., continuous in-out flow, fast filling and slow emptying, etc., and the effect of vapor pressure on loss, and generalized that emission levels are about half of API 2518 estimates. This agrees roughly with a recent German study that indicates that filling losses are 88 percent and breathing losses 11 percent of API 2518 estimates. However, no new emission formulas were developed by either program.

Two API committees, including CELM, are currently involved in a joint program, building on these recent studies, to produce a new prediction method applicable to production field tanks. This work is to be finished by the end of this year. CELM plans to expand the production tank study on completion, if necessary, to develop new correlations suitable for fixed-roof tanks in all service conditions.

A revised Bulletin 2518, "Evaporation Loss from Fixed-Roof Tanks," is planned for publication in late 1978 or in 1979.

TRUCK AND TANK CAR EMISSIONS

Emissions from these mobile sources are the final area of CELM's immediate concern. Advancements in loading methods, e.g., bottom filling vs. submerged fill pipes or splash loading, and the effect of vapor recovery units must be evaluated. The effects of Stage I service station return vapors will also affect evaporation loss. Much information on these items has already been collected by industry and regulators, and EPA has published emission factors for gasoline loading in the two Control Technique Guildlines on terminal and bulk plant operations.

CELM is currently analyzing all of the new loading data, including some quite recent truck loading tests intended to provide a more comprehensive data base. A totally rewritten Bulletin 2514B, "Evaporation Loss From Tank Trucks and Tank Cars," is scheduled for publication late this year.

FUGITIVE EMISSIONS

A related program of interest is API's fugitive emissions study being sponsored by the Environmental Affairs Department. It is not a refinery emissions study since API is cooperating with EPA and Radian in the conduct of their refinery program. The API project is determining emissions from various equipment components associated with the production of crude oil and natural gas.

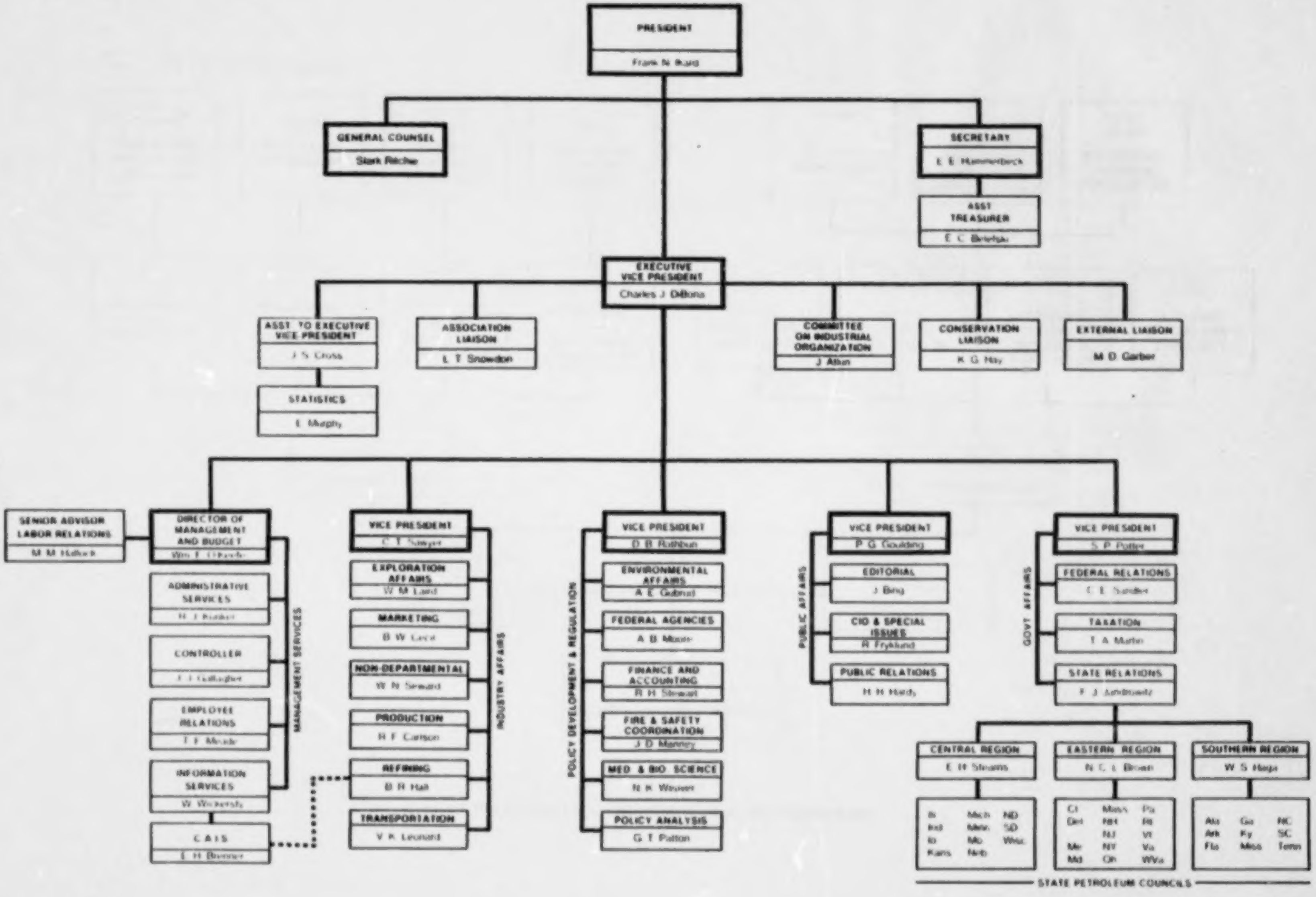
Data is being collected at twenty-one key sites which were selected to provide coverage of products and operations in four geographic regions. The Air Monitoring Center of Rockwell International is performing the work which should be completed by the end of this year. The results should offer interesting comparison with the Radian findings since some of the devices being examined in the two studies are similar.

SUMMARY

The CELM organization chart in Figure 8 shows the major areas of evaporation loss activity of immediate concern to regulators and industry.

The existing evaporation loss bulletins, originally prepared for economic comparisons, have been shown to generally overstate emissions, restricting their proper use to industry and for control strategies. All of the pertinent bulletins are in some stage of updating, with publication schedules being expedited to make the new information available as soon as possible.

American Petroleum Institute
STAFF ORGANIZATION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PUBLIC AFFAIRS
VICE PRESIDENT
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T A Martin
STATE RELATIONS
F J Ambrosetz
GOVT AFFAIRS
CENTRAL REGION
E H Stearns
Ill Ind Io Kans Mich Minn Mo Neb ND SD Wisc
EASTERN REGION
N C L Brown
Ct Del Me Md Mass NH NJ NY Oh Pa RI Vt Va WVa
SOUTHERN REGION
W S Haga
Ala Ark Fla Ga Ky Miss NC SC Tenn
STATE PETROLEUM COUNCILS
MAR 1978

Figure 1

API COMMITTEE ON PETROLEUM MEASUREMENT

JAN. 1, 1978

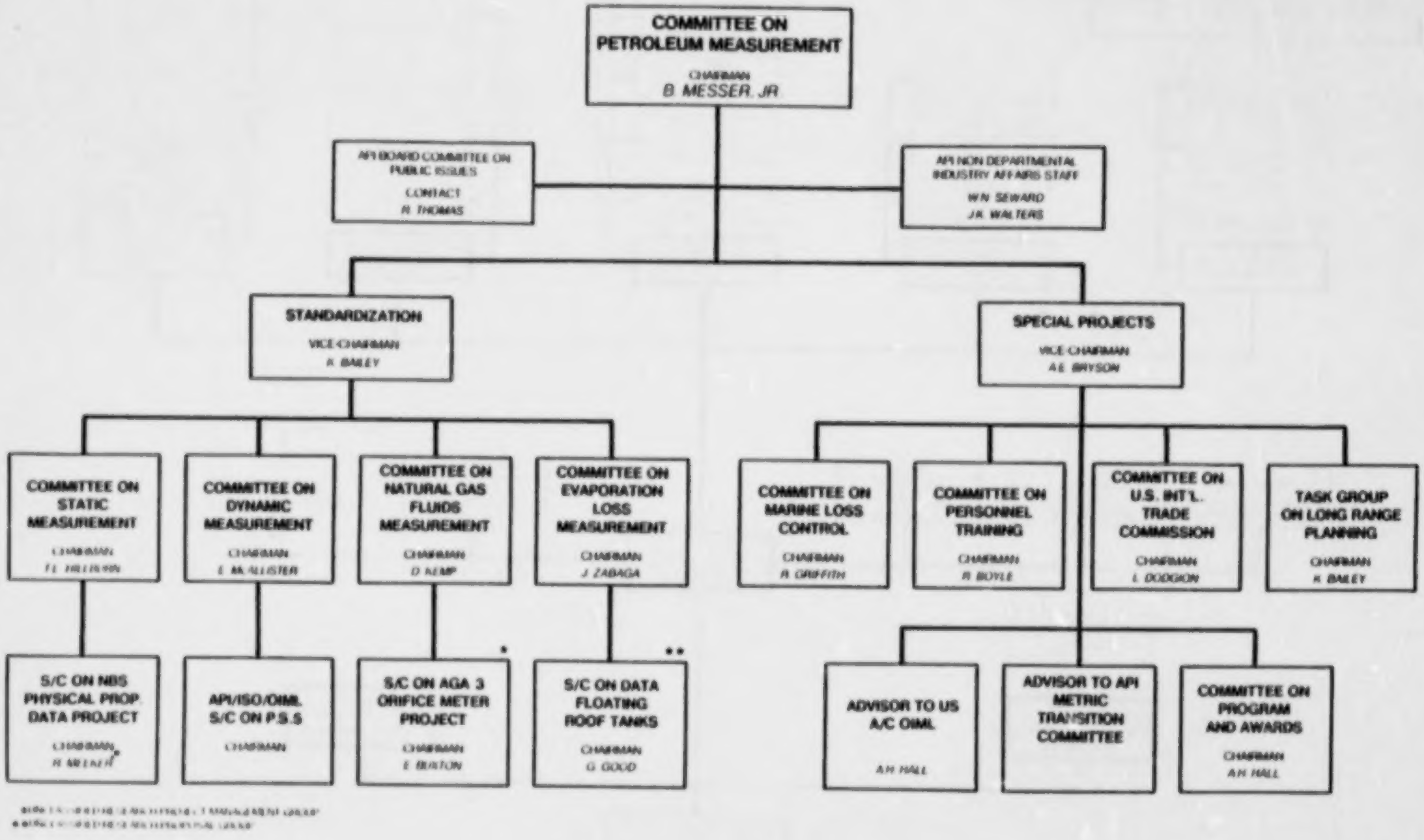

COMMITTEE ON PETROLEUM MEASUREMENT
CHAIRMAN
B MESSER, JR
API BOARD COMMITTEE ON PUBLIC ISSUES
CONTACT
R THOMAS
API NON DEPARTMENTAL INDUSTRY AFFAIRS STAFF
W.N. SEWARD
J.K. WALTERS
STANDARDIZATION
VICE-CHAIRMAN
K BAILEY
SPECIAL PROJECTS
VICE-CHAIRMAN
A.E. BRYSON
COMMITTEE ON STATIC MEASUREMENT
CHAIRMAN
COMMITTEE ON DYNAMIC MEASUREMENT
CHAIRMAN
E McALLISTER
COMMITTEE ON NATURAL GAS FLUIDS MEASUREMENT
CHAIRMAN
D KEMP
COMMITTEE ON EVAPORATION LOSS MEASUREMENT
CHAIRMAN
J ZABAGA
COMMITTEE ON MARINE LOSS CONTROL
CHAIRMAN
R GRIFFITH
COMMITTEE ON PERSONNEL TRAINING
CHAIRMAN
R BOYLE
COMMITTEE ON U.S. INT'L. TRADE COMMISSION
CHAIRMAN
L DODGION
TASK GROUP ON LONG RANGE PLANNING
CHAIRMAN
K BAILEY
S/C ON NBS PHYSICAL PROP. DATA PROJECT
CHAIRMAN
API/ISO/OIML S/C ON P.S.5
CHAIRMAN
S/C ON AGA 3 ORIFICE METER PROJECT
CHAIRMAN
E BUXTON
S/C ON DATA FLOATING ROOF TANKS
CHAIRMAN
G GOOD
ADVISOR TO US A/C OIML
A.H. HALL
ADVISOR TO API METRIC TRANSITION COMMITTEE
COMMITTEE ON PROGRAM AND AWARDS
CHAIRMAN
A.H. HALL

Figure 2

API EVAPORATION LOSS BULLETINS

API BULLETIN 2512: TENTATIVE METHODS OF MEASURING EVAPORATION LOSS FROM PETROLEUM TANKS AND TRANSPORTATION EQUIPMENT (1957)................

API BULLETIN 2513: EVAPORATION LOSS IN THE PETROLEUM INDUSTRY—CAUSES AND CONTROL (1959)..

API BULLETIN 2514: EVAPORATION LOSS FROM TANK CARS, TANK TRUCKS, AND MARINE VESSELS (1959)..

API BULLETIN 2515: USE OF PLASTIC FOAM TO REDUCE EVAPORATION LOSS (1961)

API BULLETIN 2516: EVAPORATION LOSS FROM LOW-PRESSURE TANKS (1962).......

API BULLETIN 2517: EVAPORATION LOSS FROM FLOATING-ROOF TANKS (1962).....

API BULLETIN 2518: EVAPORATION LOSS FROM FIXED-ROOF TANKS (1962)............

API BULLETIN 2519: USE OF INTERNAL FLOATING COVERS FOR FIXED-ROOF TANKS TO REDUCE EVAPORATION LOSS (1962)..

API BULLETIN 2520: USE OF VARIABLE-VAPOR-SPACE SYSTEMS TO REDUCE EVAPORATION LOSS (1964)..

API BULLETIN 2521: USE OF PRESSURE-VACUUM VENT VALVES FOR ATMOSPHERIC PRESSURE TANKS TO REDUCE EVAPORATION LOSS (1966).............................

API BULLETIN 2522: COMPARATIVE METHODS FOR EVALUATING CONSERVATION MECHANISMS FOR EVAPORATION LOSS (1967)...

API BULLETIN 2523: PETROCHEMICAL EVAPORATION LOSS FROM STORAGE TANKS (1969)...

Figure 3

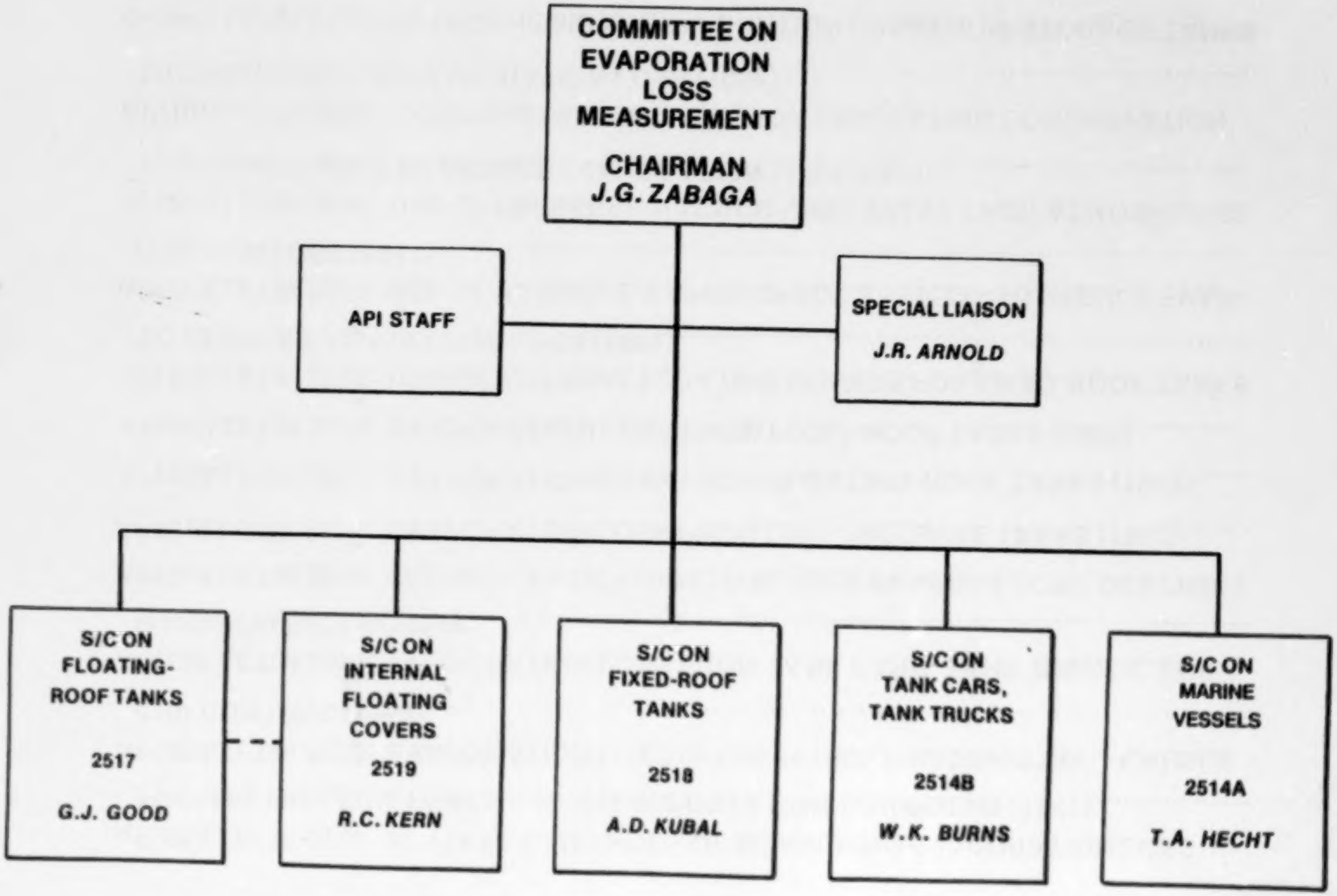

COMMITTEE ON EVAPORATION LOSS MEASUREMENT
CHAIRMAN J.G. ZABAGA
API STAFF
SPECIAL LIAISON
J.R. ARNOLD
S/C ON FLOATING-ROOF TANKS
2517
G.J. GOOD
S/C ON INTERNAL FLOATING COVERS
2519
R.C. KERN
S/C ON FIXED-ROOF TANKS
2518
A.D. KUBAL
S/C ON TANK CARS, TANK TRUCKS
2514B
W.K. BURNS
S/C ON MARINE VESSELS
2514A
T.A. HECHT

Figure 4

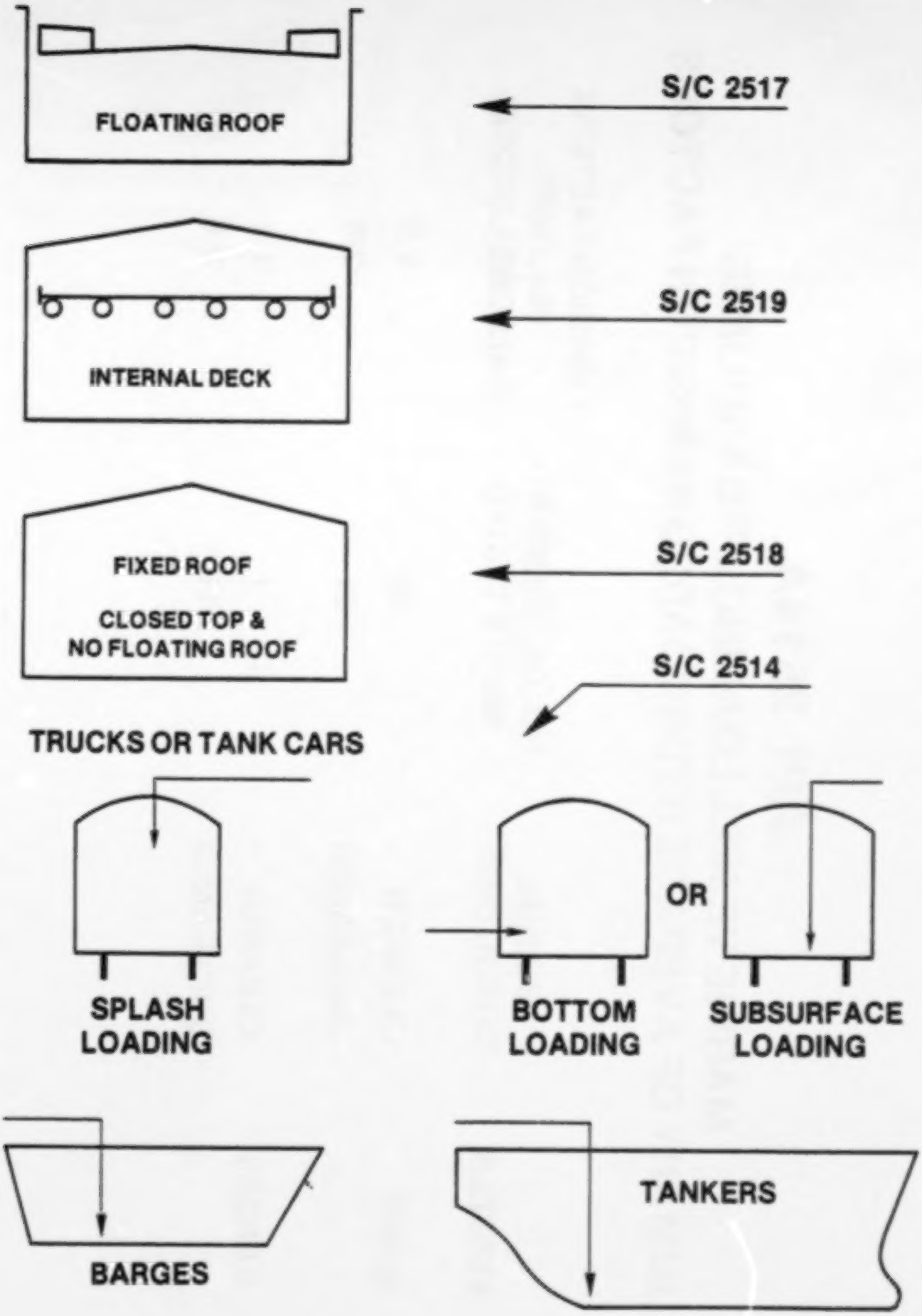

FLOATING ROOF
S/C 2517
INTERNAL DECK
S/C 2519
FIXED ROOF
CLOSED TOP &
NO FLOATING ROOF
S/C 2518
S/C 2514
TRUCKS OR TANK CARS
OR
SPLASH
LOADING
BOTTOM
LOADING
SUBSURFACE
LOADING
BARGES
TANKERS

Figure 5

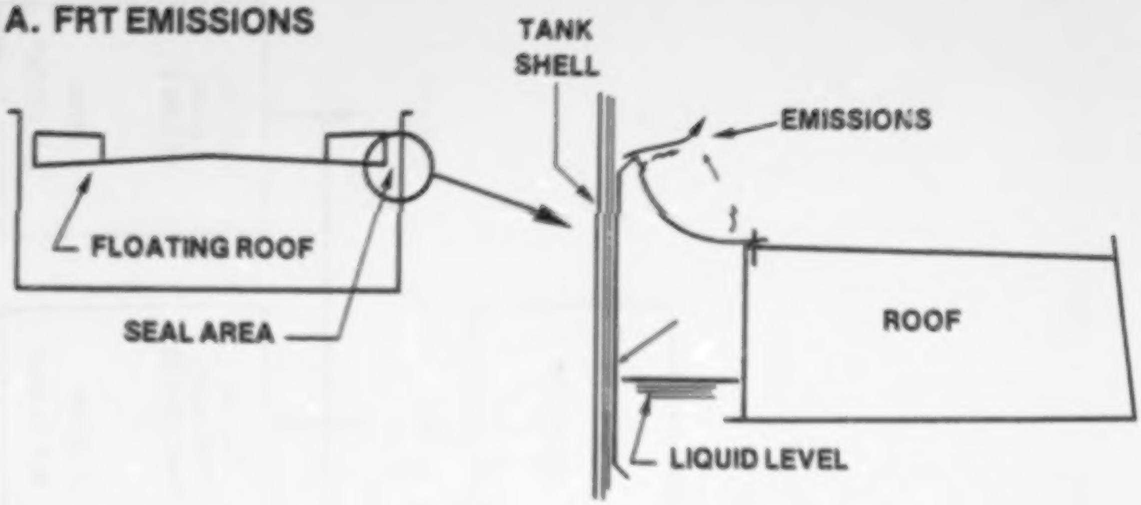
API 2514A

MARINE VESSEL LOADING OF GASOLINES
SUMMARY OF AVERAGE HYDROCARBON EMISSION FACTORS

VESSELS	ARRIVAL CONDITIONS	NO. OF COMPARTMENTS TESTED	EMISSION FACTORS (lbs./1000 GALLONS LOADED)
SHIPS	CLEANED	50	1.3
	UNCLEANED	21	2.5
BARGES	CLEANED	1	1.2
	UNCLEANED	11	3.8

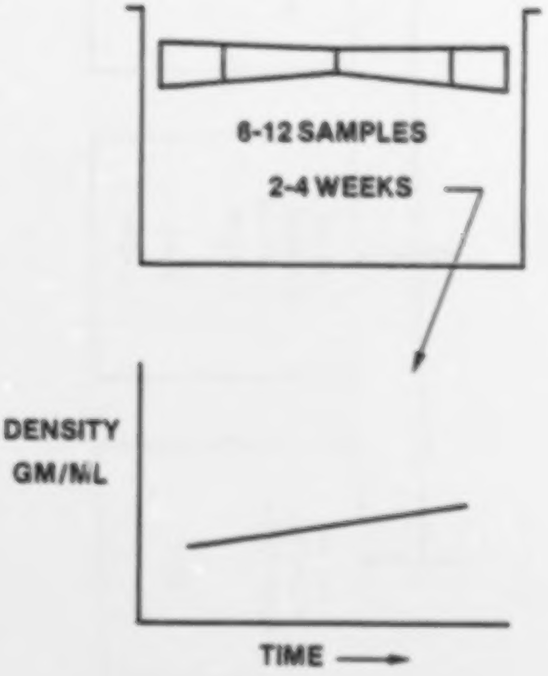
Figure 6

A. FRT EMISSIONS

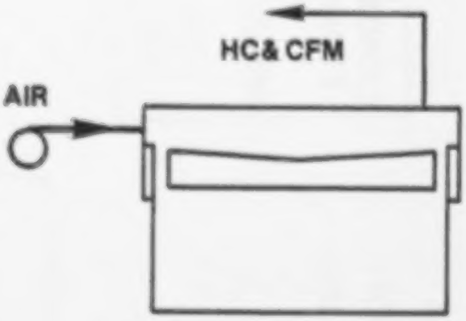

TANK
SHELL
EMISSIONS
FLOATING ROOF
SEAL AREA
ROOF
LIQUID LEVEL

B. TESTING METHODS

1. DENSITY CHANGE
   DORMANT FIELD TANKS


6-12 SAMPLES
2-4 WEEKS
DENSITY
GM/ML
TIME ⟶

2. PILOT TANK



- VARY PRODUCT, TEMPERATURE, PRESSURE, WIND EFFECT & SEAL CONDITIONS
- COLLECT & ANALYZE EMISSIONS

Figure 7

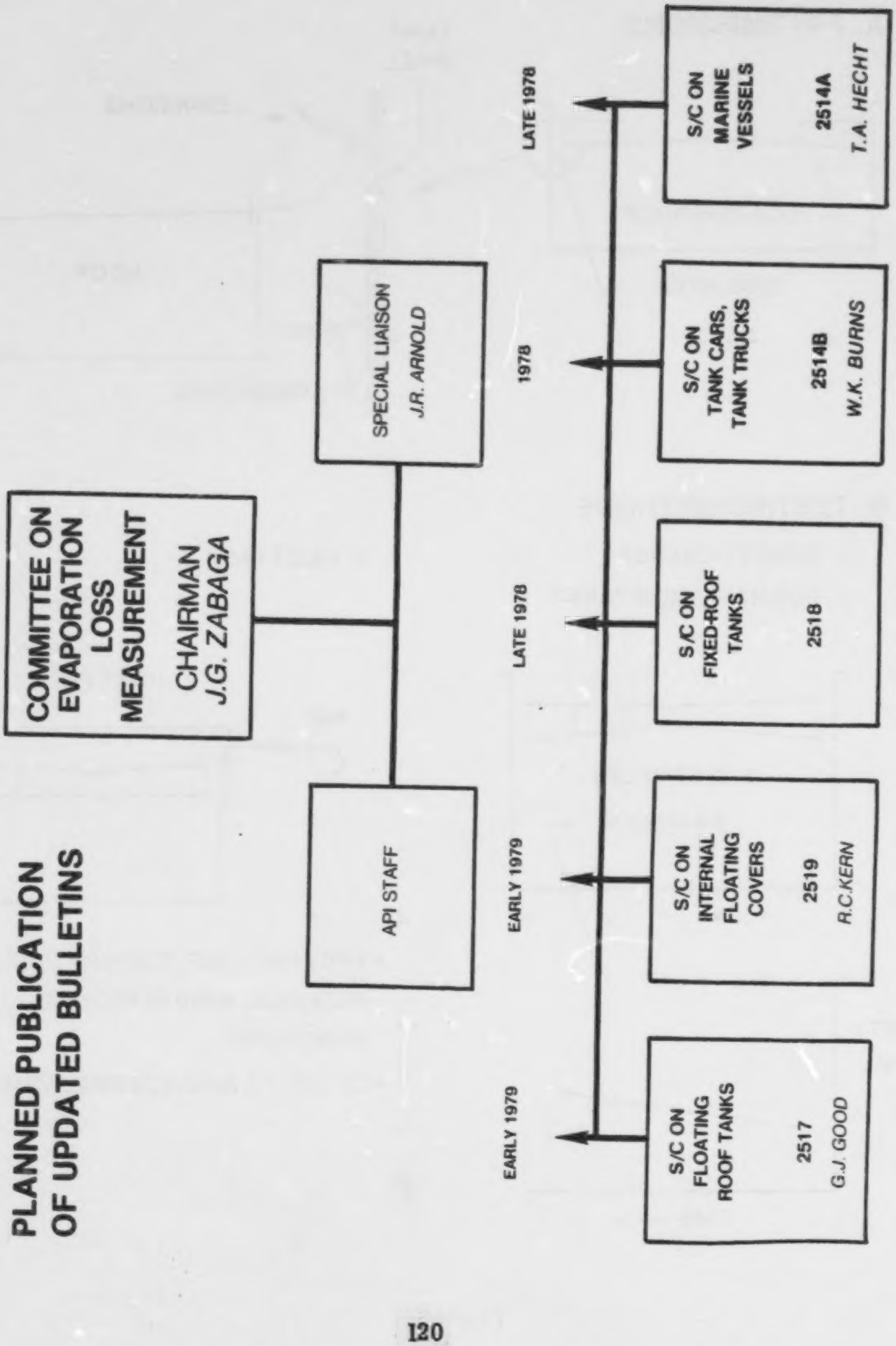

PLANNED PUBLICATION
OF UPDATED BULLETINS
COMMITTEE ON EVAPORATION LOSS MEASUREMENT
CHAIRMAN J.G. ZABAGA
API STAFF
SPECIAL LIAISON J.R. ARNOLD
EARLY 1979
S/C ON FLOATING ROOF TANKS
2517
G.J. GOOD
EARLY 1979
S/C ON INTERNAL FLOATING COVERS
2519
R.C.KERN
LATE 1978
S/C ON FIXED-ROOF TANKS
2518
1978
S/C ON TANK CARS, TANK TRUCKS
2514B
W.K. BURNS
LATE 1978
S/C ON MARINE VESSELS
2514A
T.A. HECHT

Figure 8

QUESTIONS AND ANSWERS

Q. Frank Mesich, Radian - You said excessively expensive, how expensive?

A. - Right now, we are pushing $5,000,000. That doesn't count the fugitive emission study that you are working on for EPA. I am talking just about CELM's involvement, and the work that is being done by WOGA, SOHIO and CB&I, all of which is feeding into this enormous data base. But, it is around $5,000,000. It may not sound like much for a multi-billion dollar industry, but when you start breaking it down to individual companies and individual contractors, it has created some interesting problems and justifications.

VALVES - A POSSIBLE SOURCE OF FUGITIVE EMISSIONS IN HYDROCARBON PROCESSES

Alton M. Williamson

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W-K-M Valve Division

ACF Industries, Inc.

Houston, Texas

ABSTRACT

With recent knowledge of concerns of some for Fugitive Emissions in Hydrocarbon Processes, the Valve Industry addresses this issue. Valve types, applications, and potential leak points are discussed. Installation practices, misapplications, maintenance and purchasing practices are reviewed. Existing Standards requirements and improvements in packing materials and seal configurations are studied. Other possible causes outside the valve manufacturers' control and resulting consequences are further reviewed.

RESUME

Alton Williamson received his B.S. in Mechanical Engineering from Texas A&M in 1954. He has taken graduate studies in Business Administration at the University of Houston and is a Registered Professional Engineer in the State of Texas. In 1974 he was graduated from Cornell University from their Executive Program for Advanced Management Training. For the past six years he has been employed at the W-K-M Valve Division of ACF Industries. He is now the Director of Engineering and Research. Prior to that, he acted in the capacity of Chief Engineer for nine years at a major valve company and has extensive training and experience in the field of materials, non-metallics, machining, and fabrication processes. Mr. Williamson is an active member of the Valve Manufacturer's Association serving for the past three years as Chairman of the Technical Coordinating Committee and representing VMA as Chief Technical Officer of their organization. He presently is Chairman of the Nuclear Products Committee of VMA and a member of ASME, NACE, and NMA. In his various positions, he has been instrumental in the research, design, and implementation of new valve lines including butterfly, gate, check and ball valves and, as an inventor, has several patents in the valve-related field.

VALVES - A POSSIBLE SOURCE OF FUGITIVE EMISSIONS IN HYDROCARBON PROCESSES

Gentlemen, I consider it a real pleasure and opportunity to represent the United States Valve Industry and discuss with you today the role that valves may play in Air Pollution through Fugitive Emissions in Hydrocarbon Processes.

When the VMA was contacted around the first of the year concerning an industry speaker for this Symposium, we were first alerted of pending concerns and possible studies that were to be conducted. At our Spring business meeting in Washington, D. C., in January of this year, we thoroughly discussed the request for the speaker and the pending Symposium. We further inquired of all company members of requests for information from their customers concerning this subject. Surprisingly, few had been contacted in any regards about the subject. Now that we have been alerted, we stand ready to face the issue squarely and seek the truth. Through our 72 member companies, we represent the majority of the United States valve production, and manufacture every style of industrial valve. The VMA has earned the solid reputation of being responsive to the needs of our industry, including our customers, government at all levels, suppliers, codes and standards writing groups, and other regulatory agencies. We join you in investigating this possible problem and welcome the opportunity to work with you in the future.

Now, let's look at the possible problem and, specifically, at valves:

I read and studied with interest the paper "Fugitive Emissions - Current and Projected Studies"[1], by Donald D. Rosebrook and Dr. Robert Wetherold of the Radian Corporation, Austin, Texas. This paper was just presented at the March, 1978 meeting of the National Petroleum Refiners Association in San Antonio, Texas. This paper makes many good points that merit my commenting.

First, the petroleum refining industry represents a major potential source of hydrocarbon air emissions in the United States.

Second, emissions can be classified as controlled or uncontrolled; controlled emissions being defined as those that result from stacks and vents and can be readily identified and quantified by conventional means. Uncontrolled or fugitive emissions result from leaks which can occur in virtually any hydrocarbon service. This type of emission is the one we are discussing in relation to valves.

Third, valves are listed as one of the main potential sources of fugitive emissions. One major reason is that there are so many valves in this type of service in each plant. They are also one of the easiest pieces of equipment to isolate. By using a special bagging procedure, a fairly accurate leakage rate is said to be measured; within ± 11% on methane and ± 10% on propane.

Fourth, we are generally discussing "non-visible and non-audible" leaks. This is an extremely important point. As an example, valves leaking at 150 ml/hr or less in hexane service are considered negligible. This quantity equates to .03 lb/day. Special "sniffers" used have found that unseen vapor leaks of 200 p.p.m. equates to 150 ml/hr or .03 lb/day. The real problem thus factors down to the very high number of valves used in refineries and associated industries. Over 10,000 valves per refinery is not uncommon.

SLIDE - This slide is a typical scene of the complex piping system found in so many refineries or associated hydrocarbon processing plants. Many, various styles of valves are used in this piping system.

Before we discuss prior or future proposed research into this subject, let's look at some of the various valve styles and potential leak points in the valves. A discussion of various valve end connections will come later.

Most valves have operating stems projecting from at least one point through the valve body. In addition, there may be body lubrication, by-pass or drain connections that form other pressure containment penetration points to be considered as possible points of leakage. These body lubrication, by-pass or drain connections are common in many market areas that utilize ball, gate, swing-check and globe valves.

SLIDES - The next two slides show Wafer and Swing-check Valves. Wafer-check valves usually have only one or two possible leak points excluding the flange faces. These are usually assembly holes that are used to assemble the main shaft and/or stops in the valve. These holes are usually tapped with an NPT pipe thread and plugged effectively against fugitive emissions.

Swing-check valves may have screwed, bolted or clamped bonnets, depending upon the design. The clapper shaft may penetrate the pressure containment boundary in the body. Again, body fittings may be employed as by-pass relief around the clapper, or for other purposes. The bonnects may have metallic or non-metallic seals, many being simple flange-type connections.

SLIDE - The Diaphragm or Weir-type Valve.

This valve has a screw-type stem with either fixed or adjustable seals around the stem and static seals at the bonnet.

SLIDES - Plug Valves.

Plug valves can be cylindrical or tapered, top or bottom entry, with fixed or adjustable seals and packing. This first slide shows a bottom entry valve with a metal seal at the entry opening of the plug. The top of the plug is sealed with a simple dynamic seal that is both pressure energized and mechanically energized by the plug support spring.

This second version shows a top entry valve with adjustable packing gland. An external injectable sealant provides the downstream seal and assists in sealing externally in both versions. The lubricant injection system is effectively sealed with check valves to prevent emissions backward to the atmosphere.

SLIDES - Globe Valves.

The Globe valve is one of the oldest and most used type valves.

SLIDE - The globe valve also is capable of being furnished with fixed or adjustable packing around the stem. Its bonnet also can be of various types of construction.

SLIDE - Many types of globe valves, in both straight through and angle-type, are excellent in throttling service and can be a fixed position handwheel-type valve or an automatic regulating diaphragm-actuated valve.

SLIDES - Butterfly Valves.

SLIDE - Most Butterfly Valves have stems penetrating both the top and the bottom of the body. The most popular butterfly valves today, are, of course, the wafer style. Wafer-style valves may have flange seals built into the sealing element of the valve itself. Many butterfly valves have O-rings, or other sealing elements between the stem and body. They also may have primary seals between the disc and the seat or sealing element in the valve, with additional O-rings on the stem or shaft as secondary sealing members.

SLIDE - This body construction is also popular in the wafer-type check valve, which we looked at earlier. The wafer-style valve comes in several configurations, but basically, the true wafer is one that simply slips between the flanges and is centralized by the bolts in the flanges, and held in place by the compression that flange bolting exerts on the valve body.

THREE SLIDES - There are three other thin body styles which are commonly referred to as the semi-lug body style, lug-body style, and the flanged body style. The lug-body style is a wafer-type valve, that has threaded lugs around the periphery of the body, that allows bolts or studs to be utilized to hold the valve to a single flange. For low pressures, this style or the flanged style valve may be utilized as a Stop valve at the end of the line, depending on the individual design.

SLIDE - The Butterfly valve can also be furnished with adjustable packing glands around the stem of the valve.

SLIDE - Some designs also have pressure-energized seats, which affect sealing from either direction in the valve.

SLIDE - This slide shows a common seal for the lower end of a high performance ANSI Class Butterfly Valve. This particular type valve is one of the fastest growing valve styles in the industry.

SLIDE - Ball Valves are commonly referred to as spherical plug valves. Like all valves, they come in assorted styles, shapes, and configurations. They, like the butterfly valve, may have stem seals of simple O-rings, or other fixed packing, as well as adjustable outside packing boxes.

SLIDE - Ball valves may be of the floating style, where the weight of the ball is carried by the sealing elements and line pressure forces the ball against the downstream seat.

SLIDE - The shaft or operating stem protrudes through the top of the valve and is sealed at the body. This type valve is generally a downstream sealing valve.

SLIDE - There are also trunnion-type ball valves, where the ball is carried in a relatively fixed position by the shaft extending through the top and bottom of the valve. This style has seats which are energized by pressure. The valve is generally an upstream sealing valve. The ball valve type is one of the most popular styles of valve being utilized in all types of industry today. Its future in hydrocarbon processes will continue to be brightened as further progress in technical advances are made in the development of this style valve.

SLIDES - These slides show various styles of Gate Valves. Basically, they are variations of the wedge-type gate valve, and a through-conduit gate valve.

SLIDE - The basic difference between the two being that in the through-conduit gate valve, the seats are protected in both the full open and the full close position.

SLIDE - Most gate valves are furnished with an adjustable outside packing at the stem, with some low pressure styles for less critical service being furnished with O-rings or other fixed type packing.

SLIDE - The packing glands may be conventional stuffing boxes, with a myriad of various types of materials to choose from. However, they can also have external, injectable plastic packing sealing capability, as we will see later. They can also have a way to remove any minute leakage around the stem, for disposal through a waste-process system.

SLIDE - Bonnets, again, vary from clamped, screwed or flanged, with the most popular by far being the flanged bonnet with either metallic or non-metallic-type of gasket. This valve is furnished many times with body fittings, for either purging operations, by-pass around the gate, or simply a drain or for leak checking or other purposes.

Up to this point, we have discussed, basically, shut-off or block-type valves. Although a simple on/off block valve can also, in many cases, be used for throttling, there is a special flow rate control-type valve. These are commonly referred to as Control Valves. They may be a globe style, a butterfly, a ball, or some other configuration, but they're designed and sold primarily for flow control. In addition, we have seen that there are flow direction control valves which are commonly referred to as check valves. These can be referred to as a one-direction stop-type valve.

SLIDE - In addition, there is one other type valve, as shown in this slide, which is commonly referred to as a Pressure-Relief Valve. These valves are block valves, and are intended to open upon a predetermined over pressure condition. They may or may not be piped to a waste collection or process area. If not, their internal sealing means becomes a source for fugitive emissions investigations.

Now that we've looked at styles of valve construction and the basic types and some of their general applications, can we draw any conclusion? Basically, the conclusion can be made that although valves have varying degrees of potential leak points, the main point of susceptability for a valve in a closed system, that is one that is not being used on the end of the line or as a safety relief valve, becomes the stem packing area. Bonnet flanges are a possible source of fugitive emissions also, but generally, not subject to exaggerated movement, except for process induced vibrations, and consequently, less of a suspect for leakage.

Let's touch on end connections of valves. Basically, these may be flanges, threads, welds, or clamp hubs. These connections are not limited to valves, because there are many more points of leakage in a refinery or process plant piping system than at the valves. One of these multitude of potential leak points is flanges.

SLIDES - The next two slides should be readily recognizable to most of the people here. They are merely design criteria of the various styles of gasket materials and contact facings, or flanges, as depicted in ASME, Section VIII Code. These are readily acceptable in industry today, when utilized with standard flanges. Many have proven themselves when tested under extreme high pressure gas and with helium. It is my suggestion and recommendation to those who propose to undertake fugitive emissions leakage studies for the future, that they also isolate this component from other equipment, such as valves and pumps. I think we ought to know what truly is or is not causing problems of hydrocarbon emissions. The same general comment can be made for standard pipe thread connections and any other special clamp or threaded connections, where utilized in process piping for whatever reason.

Now let's look at the possibility that valves may be a major source for fugitive emissions. What would cause this? Valves manufactured from the majority of the U. S. valve manufacturers today will meet any standard industry recognized test that you care to give the product at the time of acceptance. That is, the product will meet its intended use. Therefore, if valves are actually a problem in fugitive emissions, it must be something that happens after shipment that causes the problem. I submit that the major problem is age, lack of proper maintenance and misapplication. There are many installation practices and purchasing and specification practices that are questionable. Too many purchasers of valves look upon all types of valves as simply commodity items, that can be installed with any process, as long as the combination of pressure and temperature is within the range as established by the manufacturer. This is simply not true. The results are often premature failures, caused by the misapplication, and many times, the valve manufacturer is not even called in to help or even notified of the problem. This is one of the biggest hindrances in user/manufacturer relations that stymies further development and progress in valve improvements. It is imperative that valve manufacturers and their customers work closely as a team for the benefit of both in the future.

We are all getting older. As I grow older, this old body begins to wear out. My automobile has to be serviced regularly. Even parts that are not discussed in the automobile repair and service manuals, wear out due to age and lack of maintenace. With, in many cases, over ten thousand valves in a large refinery or process plant, and with automation coming of age as it has, how do you perform the maintenance on all of the valves that you have in a plant; much less set up a preventive maintenance program? From the manufacturer's standpoint, I recognize that this must be an enormous task. But remember, we're discussing emissions that normally can't be seen, nor heard. Therefore, the problem of maintenance becomes extremely important.

This brings up other problems that need to be discussed. Most domestic valve companies know their products extremely well. They don't guess at the recommendations that they make, as their experience in both laboratory and field testing, along with many years of successful product applications, give them confidence in their recommendations. They recommend spare parts for valves. These spare parts are "genuine" spare parts as made by the American valve manufacturer. They are expected to and do work in the valve for which they were manufactured. Outside of the basic valve manufacturing industry, there are many, what I refer to as, "backyard valve repair shops". Many of them have names that say "valve manufacturer". They are in the business to service valves, most of which they do not make. They sell these services on the basis that they know more about valves and their applications than the valve manufacturers do. They cannot know the need for exact parts size, much less tolerances, the required surface finish, or necessary configurations of the various parts, nor proper maintenance intervals, procedures or proper materials. Any yet, they are utilized by legitimate, major companies in the U. S. every day. When most valve manufacturers not only stock and sell original and guaranteed parts for their products, they generally have a well-educated and trained valve service department of their own. Many companies have these service organizations world-wide and can give quick and professional service.

In addition, there are also companies now selling "on-line" leak sealing capabilities. They are found selling their services in refineries, process plants, and yes, even fossil fuel and nuclear power plants. These service companies come into a plant, by invitation. Without valve manufacturers' knowledge, they will drill holes into areas of packing glands and stem sealing areas, so that some kind of a special seal can be pumped into the leaking area to stop a leak. Since a packing gland feature is available in many domestic valves as a standard or an option that negates the need for this service, why should it be necessary after the valve has been installed, to ever perform such an emergency service? Was it a misapplication? Was it a poor choice in the valve for the service? Again, the valve manufacturer is seldom, if ever, contacted concerning this problem.

Other purchasing practices must be questioned. First consider the fact that many large, honorable valve user companies have explicit performance requirements for valves that they approve and list in their Engineering Standards. It requires extensive test time on the part of the valve manufacturer to prove that his product will, in fact, meet the criteria. When it does, he expects to participate in the business available within the boundaries of the free enterprise system. I can assure you that often he cannot, because the buying practices of companies often completely ignore their own Engineering and Quality Assurance Standards for use of acceptable quality valves. This is a cause of valve misapplication in process plants. This, also, brings in an even more important issue - Foreign Produced Valves.

I represent the United States Valve Manufacturers Association. I know for a fact that foreign manufactured valves are a source of technical problems in process plants. I will not even address the economic problems, even though they also greatly affect the valve user. I will also agree that there are some excellent quality foreign-produced valves. But, have they passed equal quality testing programs as required of U.S.-produced valves? Is technical support, both in the form of qualified people, spare parts and service, readily available to the user?

A large refinery was persuaded to purchase over $3,500,000 worth of foreign valves. I ask you, what could be the fugitive emissions problem from the following factual results?

(1) Casting porosity in several valves that worsened as production temperatures and pressures were applied.
(2) Valves developed "stretched" or "bowed" yokes.
(3) "T" head assembly sheared off and disengaged from sealing member.
(4) Valve bodies were worked and stretched to a point where repair was impossible.
(5) Sealing members seized in position resulting in stems breaking or stripping of stem bushing, not threads.

We won't even take time to discuss the liability problems of the prior examples. But to reduce all types of leakage, whether miniscule fugitive type or other, and to reduce risk of a fire, explosion, or other disaster in a plant, you must have the best quality valves that you can get and depend upon.

Let's look now at a few special modifications and some results of other work done in the valve industry leading toward improved equipment.

SLIDES - These next two slides show various types of seals that can be utilized in valve bonnets, flanges or any area where two mating parts must fit together and form a seal. There are so many excellent designs being utilized today, that it is impossible to list even more than these few. You will recognize that several of these, such as those marked with the asterisk, are pressure-energized seals. The basic idea of utilizing pressure-energized seals is one that should be pursued more and more in the future.

Much work has also been done in improving basic seal materials, style and configuration. Many excellent variations are available, with the only real hinderance being one of past specification and established purchasing habits. Excellent work has been done in laminates, ribbons and filament braid packings.

SLIDE - This slide shows a schematic of a grease or sealant injection system at the lantern ring, in the packing area around the stem of any conventional valve. The slide says "Gate or Globe Valve". However, it's applicable to any type valve.

TWO SLIDES - Here is a slide of an actual valve design, while the next slide shows a standard packing box, both with and without this feature. This is a standard feature in many valves, and is probably not used on more valves for only two reasons: (1) customers decide they don't need it and (2) it makes the product cost more. Probably, there are places where it is not needed, but here is one simple scheme where all you have to do is inject a sealant under pressure, and you eliminate leakage just due to keeping a higher differential pressure in the packing than you have on the inside of the valve.

SLIDE - This slide shows a typical wedge gate valve, utilizing a pressure-energized bonnet seal.

There is another idea that has been used in industry for years, although you don't see it on many standard valves in plants today. That idea is to eliminate the packing around the stem on the primary seal by the use of bellows or other means.

TWO SLIDES - These next two slides show typical straight through and "Y" pattern globe valves with bellows sealed bonnets. This is sometimes referred to as a "packingless valve". This does not mean that there is not a potential leak path at a bonnet.

There are also all welded valve body designs on the market that have readily been used in general pipeline transmission service. These designs eliminate body joint connections such as flanges.

We have discussed fugitive emissions as a possible problem, defined minimum suggested leak rates, looked at basic valve designs, possible leak paths, valve user contributed problems, and a few valve seal improvements. But we must now ask the question, "Is the need real"? How far are we to take investigations of fugitive emissions? What price is the United States of America ready to pay for this type of emission control? Are we going to eliminate all of our forests and woodlands? Trees give off hydrocarbons, also. The Blue Ridge Mountains are "Blue" and the Smoky Mountains "Smoke" for a reason. We can solve any problem for a price.

Time, today, simply didn't allow an adequate coverage of such an immense subject from the valve industry point-of-view. Trying to consolidate into a 20-minute talk, an adequate discussion of this magnitude, is extremely difficult. However, I can tell you that our valve members are equipped with excellent research facilities, testing laboratories, and the proper manpower to make use of the facilities. I can also assure you that the valve manufacturers of the United States want to do more than to sell valves. They want to offer service, as well. We have never ducked a challenge. We face all issues squarely. I assure you that valves being built today are better than ever before, with new developments every day to make seals, packings and sealing elements more reliable, longer lasting, and overall more dependable than ever before. I must, also, leave with you the honest conveyance that the valve industry wants to work for improvement of its products. Your assistance is appreciated.

ACKNOWLEDGEMENTS AND REFERENCES

[1] Rosebrook, Dr. Donald D. and Wetherold, Dr. Robert, "Fugitive Emissions - Current and Projected Studies", from a paper presented at the 1978 NPRA Annual Meeting, San Antonio, Texas, March 19-21, 1978.

[2] Acknowledgement is made to the Officers and Member Companies of the Valve Manufacturers Association for their assistance in supplying information for this paper.

QUESTIONS AND ANSWERS

Q. - J. Daily, Chevron - On the bellow valve, what percentage do you sell and what is the operating limit?

A. - I can't answer that, I have to speak for a group of 72 that I represent, and I don't make a bellows seal valve and I would defer to somebody else.

Q. - A. T. Kott, TACB - I have a question on the cost of spray packing versus putting a little chamber in there with a tap like the cooling chamber you have versus the cost of the bellows. Are the bellows half again the cost of the valve?

A. - I can't speak for the bellows. I know they exist. I know that they are not widely used. It is a possibility.

Comment - R. Smith, Xomox - The bellow seal valve is very expensive and is only used basically in the globe-type of construction. You have to control the amound of head due to the fact that you could overstress the bellows. The valve is only used in very exotic circumstances and is primarily in small size valves. Two inches are relatively large bellow seal valves. I don't believe the bellow valve is particularly applicable to the industry.

A. - Your first two parts of the question I can readily answer because I am very familiar with it. It really doesn't cost that much more to put the extra feature in there to be able to have plastic injectable packing. Every oil well valve has got them and I predict that when you measure emissions out there, you are going to find that the fugitive emissions around oil wells, whether offshore or onshore, are much samller than what you have found so far, because of this type of valve. Plus everything is a metal-to-metal seal otherwise.

Q. - R. Vincent, CARB - In your opinion, would current valve technology and the expertise of the manufacturers in recommending certain equipment and certaim maintenance practices suffice to essentially eliminate valve leakage in refineries and related industries?

A. - I believe it would. If we tested in our plant, tommorrow, just before a valve left, I believe we'd find that these new valves do not leak. Even if they are the simple low-pressure O-ring seal valve.

Q. - R. Vincent - Do you think this would entail any significant extra capital expense on an on-going basis for refineries? Are we talking about fancy valves and expensive materials?

A. - It is going to cost them a little more, but not so much from the valve standpoint as it is from other areas that they have already addressed. That is, they are working hard on maintenance, more than just tightening down nuts. But, when you get to rebuilding valves that you have got to shut down for, those are real problems.

PLANS FOR ASSESSMENT OF WATER AND RESIDUALS EMISSIONS FROM THE PETROLEUM REFINERY

Fred M. Pfeffer
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ABSTRACT

The Environmental Protection Agency will prepare a document which assesses the emissions from a petroleum refinery via wastewater effluent discharge and residuals from wastewater treatment. The mechanism for preparing this report, the topics covered, the factors considered in making the assessment, and some of the information to be utilized in preparing the assessment will be discussed.

RESUME

Our final speaker for the program is Fred Pfeffer from IERL, Ada, Oklahoma Laboratory. Fred got his B.S. and M.S. Degrees in Chemistry from the University of Cincinnati and he has over 15 years professional experience in wastewater treatment with EPA and its predecessor organizations.

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Fred M. Pfeffer

PLANS FOR ASSESSMENT OF WATER AND RESIDUALS EMISSIONS FROM THE PETROLEUM REFINERY

The EPA Office of Research and Development will prepare an assessment of the emissions from the industrial point source--the petroleum refinery. Two EPA laboratories are cooperating in this effort and will assemble a final EPA document: IERL, RTP on air emissions; the Robert S. Kerr Environmental Research Laboratory on emissions from wastewater effluents and from the residuals from wastewater treatment. The products of the two laboratories will be independent parts of the overall assessment; e.g., documents a, b, c carrying the same EPA report number.

The reports on wastewater and residuals emissions will be based upon existing information and will contain chapters on the following topics:

a) State-of-the-Art Discussions

1. A characterization of and future trends for the petroleum refining industry, including the parameters affecting generation of pollutants such as crude source, process units, operation (refinery classification), upsets, turnarounds, and wastewater treatment systems in use at the refinery.

2. An evaluation of existing and emerging treatment and control technology applicable to refining wastewaters.

b) Rationale for Characterizing the Wastewater and Residuals Emissions

Several different approaches have been or are being considered to assess the pollution potential of refinery waste discharges. In the case of wastewater, the classical permit parameters such as COD, chromium, suspended solids, sulfide, cyanides, and oil and grease have been in common use for such assessments. Use of the more recent "priority pollutants listing" is another approach. Other concepts are effects-oriented, using such techniques as fish toxicity, bioassay, biodegradability (or persistence), carcinogenicity, mutagenicity, and teratogenicity. A rationale considering all of these assessment techniques will be presented in the form of a pollutant "punch" list. In the case of residuals, leachability of toxic or hazardous substances is an important consideration. Any pollutant's assessment is method-dependent; therefore, a measurement procedure will be referenced for each pollutant defined.

c) Emission Data

Available information on the occurance, quantities, sources, and avenues of emissions of pollutants will be presented. Wherever possible, this compilation will include accuracy, precision, and variability for both physical and chemical measurements techniques.

d) Criteria

Criteria will be presented for the current environmental impact of pollutants, establishing levels in emissions and in the environment. Use will be made of existing regulations, not necessarily limited to those of the EPA.

e) Environmental Assessment

A comparison will be made of pollutant emissions to the criteria, and a statement as to level of treatment and control (T&C) requirements for obtaining criteria levels will be attempted for each pollutant.

f) T&C Evaluation and Research Needs

Existing and emerging T&C systems will be evaluated relative to the acceptable emission levels, and T&C research needs will be identified.

The mechanism for producing these reports will be a research grant utilizing recognized experts for the preparation of each chapter. A consortium of experts will be assembled to prepare the criteria for environmental impact and acceptable pollutant levels.

Data available to the grantee is largely composed of wastewater emissions information (as opposed to residuals) and is the result of the Robert S. Kerr Environmental Research Laboratory's program of T&C research in the refining category conducted in cooperation with various API committees. The major studies are as follows:

a) Raw waste load and final effluent characterization at refineries representing 85% of domestic refining capacity was completed in 1972.

The study was specific for 22 common wastewater parameters and included an investigation of the treatment efficiencies across five activated sludge systems. The following tables show the classes of refineries monitored (Table 1), the parameters measured (Table 2), the performance of activated sludge treatment (Table 3), and final effluent loadings (Tables 4, 5).

b) In December 1976, a study was conducted at SOHIO (Toledo) to determine the major individual organic compounds entering and leaving each of three treatment systems in series: full-scale activated sludge; pilot scale mixed-media filtration; and pilot scale activated carbon. The study was conducted through an interagency agreement with ERDA (Argonne Laboratory, Chicago); the draft final report is under review. Prior to utilization for the assessment, Argonne's analytical results will be compared to split sample results of EXXON R&E (for the API) and SOHIO. Figure 1 shows the sampling points in the study.

c) The Robert S. Kerr Environmental Research Laboratory's participation in a "Priority Pollutants" study for EPA's Effluent Guidelines Division (EGD) was completed last year. Twelve refineries were sampled to characterize and semi-quantitate the priority pollutants entering and leaving the treatment system. Analytical results from laboratories under contract to EGD are not as yet complete. Table 6 shows the refineries visited; Table 7 presents the priority pollutant sampling information. The API sponsored similar studies at four refineries and has indicated that this information may be considered a source for the assessment.

d) Also for EGD, the Robert S. Kerr Environmental Research Laboratory is conducting an indicatory fate study to determine the mechanism whereby an activated sludge system removes the polynuclear aromatic compounds (PNA's) found on the priority pollutant list (e.g., via wasted solids; sparging to the air; or biodegradation). One refinery has been sampled extensively; the in-house study is in the sample preparation stages prior to final GC/MS analysis. Figure 2 shows the sampling points; Figure 3 is an engineering drawing of the air sampling device. The specific organic compounds studied are found in Figure 4. Two gas chromatograms are reproduced in Figure 5 for comparative purposes. At the bottom of the figure is a chromatogram of the PNA compounds of interest. The upper tracing is a chromatogram of a waste sample collected during the study, showing graphically the analytical problem of determing a few specific materials in a complex matrix of organics in wastewater. The API has sponsored PNA studies at a refinery and a publically-owned treatment works and has indicated that this information will be available for the assessment.

There is very little information available for residuals relative to that for wastewater. Most of the research concerning residuals has dealt with oily rather than biological sludges. Two studies have been sponsored by the API to characterize the sludges found in a refinery: a study by Jacobs Engineering in 1974, and a much more extensive study involving over 70 refineries conducted in 1976. The API has indicated that these studies when published will be available for the assessment.

The target date for completion of the Laboratory's portion of the overall assessment is September 1979. This will not be in time to impact the revised Development Documents for Petroleum Refining relating to wastewater and solid waste; however, assessment may prove useful in the mandated revision process of these documents.

Table 1. CLASSIFICATION OF REFINERIES MONITORED BY EPA

REFINERY CLASS	QUESTIONNAIRES RECEIVED	REFINERIES MONITORED	
		NO.	CRUDE CAPACITY BPSD
A	14	2	13,200
B	79	8	424,400
C	31	3	388,500
D	12	2	397,300
E	14	2	702,000
	150	17	1,925,400

Table 2. ANALYTICAL PARAMETERS

BOD_5
COD
TOC
PHENOL
SUSPENDED SOLIDS
DISSOLVED SOLIDS
pH
ALKALINITY
ACIDITY
OIL & GREASE
T. PHOSPHORUS
AMMONIA N
KJELDAHL N
NITRATE N
CHLORIDE
CYANIDE
SULFIDE
T. CHROMIUM
IRON
COPPER
LEAD
ZINC

Table 3. PERFORMANCE OF ACTIVATED SLUDGE TREATMENT

	INFLUENT (mg/l)			EFFLUENT (mg/l)			% REMOVAL
	MAX.	MIN.	MEDIAN	MAX.	MIN.	MEDIAN	(MEDIAN OF ALL DATA)
BOD_5	228.0	27.0	85.0	53.0	5.0	8.0	89.2
COD	583.0	93.0	213.0	201.0	46.0	70.0	54.6
OIL & GREASE	89.0	8.0	29.0	37.0	4.0	11.0	60.0
PHENOL	16.0	0.26	3.4	4.2	0.01	0.01	99.6
TSS	261.0	15.0	36.0	83.0	5.0	25.0	23.8
SULFIDE	43.0	0.10	2.9	1.7	0.0	0.3	90.0
pH (units)	11.5	6.2	8.8	8.7	5.0	7.3	—
AMMONIA N	160.0	6.0	12.0	124.0	0.05	11.0	16.2
KJELDAHL N	194.0	8.0	17.0	134.0	2.0	15.0	17.2
CYANIDE	2.5	0.02	0.2	0.03	0.02	0.1	30.9
T. CHROMIUM	4.25	0.03	1.43	1.45	0.02	0.26	58.2
IRON	44.0	0.50	1.02	0.50	0.18	0.78	37.1
COPPER	0.88	0.02	0.14	0.11	0.02	0.05	57.7
LEAD	1.73	0.00	0.10	1.04	0.10	0.11	0.0
ZINC	1.23	0.07	0.22	1.84	0.04	0.16	22.0

Table 4. FINAL CLARIFIER EFFLUENT LOADING (FIVE PLANT COMPARISON)

		MEDIAN LOADING (lb/1000 bbl)			
	9973	2115	0288	6512	6693
BOD_5	5.5	3.1	3.9	4.0	1.5
COD	42.0	22.0	49.0	16.0	23.0
OIL & GREASE	9.2	2.8	7.1	2.9	2.4
PHENOL	0.006	0.006	0.006	0.003	0.002
TSS	17.0	4.0	14.0	7.9	6.4
SULFIDE	0.10	0.05	0.32	0.13	0.04
AMMONIA N	4.1	17.0	7.5	0.1	5.8
CYANIDE	0.06	0.01	—	—	—
T. CHROME	0.025	0.078	0.136	0.085	0.210
IRON	0.480	0.148	0.330	0.083	0.650
COPPER	0.032	0.005	0.015	0.014	0.030
LEAD	0.397	0.018	0.064	0.030	0.046
ZINC	0.086	0.027	0.036	0.059	0.089

Table 5. FINAL CLARIFIER EFFLUENT LOADING (SUMMARY OF ALL DATA)

	MEDIAN LOADINGS (lb/1000 bbl)	STANDARD DEVIATION OF LOADINGS (% of median)
BOD_5	3.9	55
COD	23.0	21
OIL & GREASE	2.9	41
PHENOL	0.006	1100
TSS	7.9	44
SULFIDE	0.10	97
AMMONIA N	5.7	31
KJELDAHL N	7.5	25
CYANIDE	0.04	24
T. CHROME	0.083	29
IRON	0.330	29
COPPER	0.015	26
LEAD	0.046	20
ZINC	0.059	55

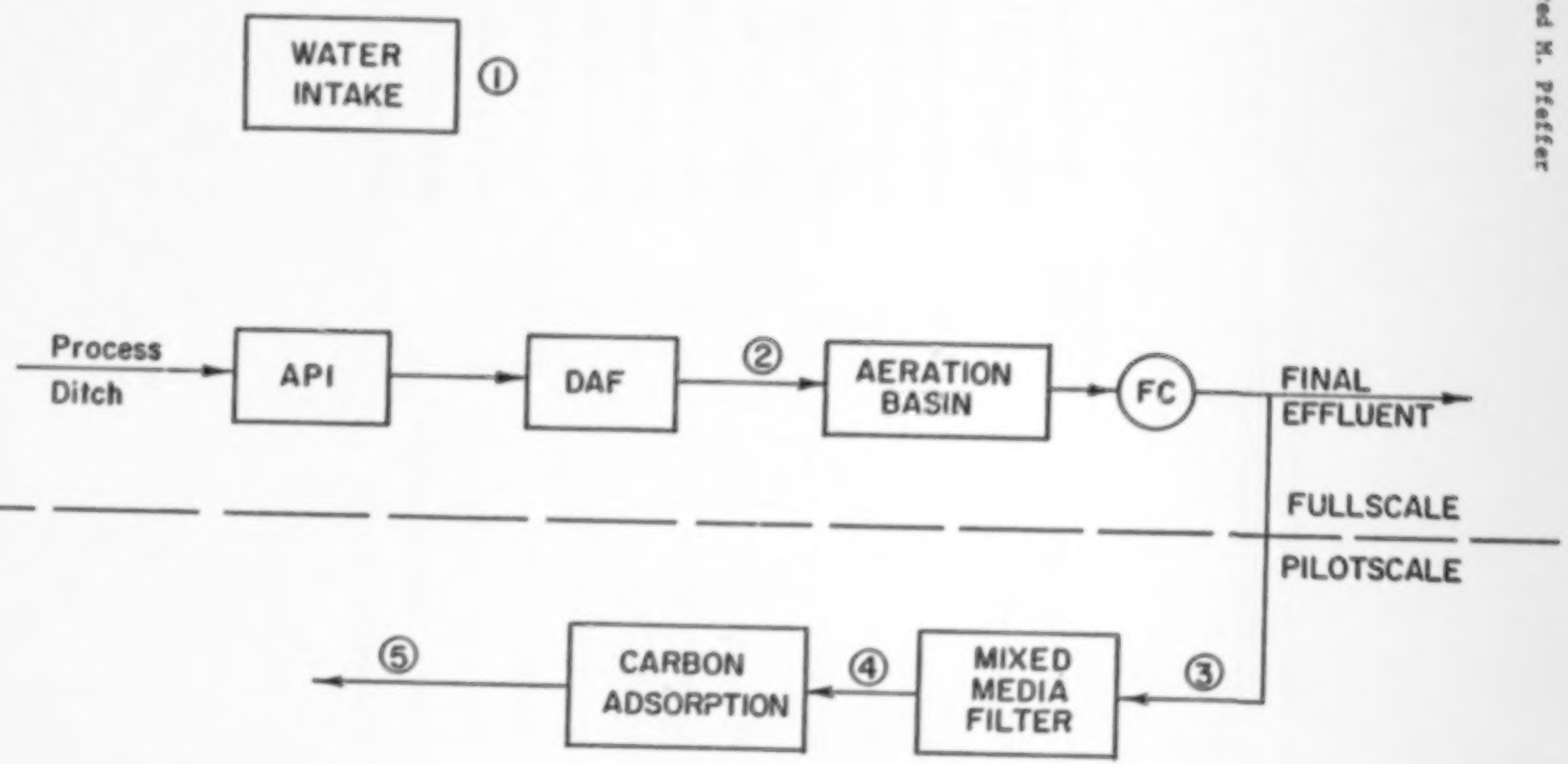
WATER INTAKE
①
Process Ditch
API
DAF
②
AERATION BASIN
FC
FINAL EFFLUENT
FULLSCALE
PILOTSCALE
③
MIXED MEDIA FILTER
④
CARBON ADSORPTION
⑤

Figure 1. Sampling points for 1976 study.

Table 6. REFINERIES VISITED

Refinery	Location	Refinery Class	Treatment System
Gulf	Philadelphia, Pa.	C	Trickling Filter Activated Sludge
Exxon	Baytown, Tex.	E	Aerated Lagoon
Hunt	Tuscaloosa, Ala.	A	Activated Sludge
Clark	Hartford, Ill.	B	Activated Sludge, Filtration
Texaco	Lockport, Ill.	B	Activated Sludge
Mobil	Augusta, Kan.	B	Oxidation Ponds
Phillips	Sweeney, Tex.	C	Aerated Lagoon
Shell	Anacortes, Wash.	B	Activated Sludge
Exxon	Benecia, Calif.	B	Activated Sludge
Exxon	Billings, Mont.	C	Aerated Lagoon
Coastal States	Corpus Christi, Tex.	C	Activated Sludge
ARCO	Philadelphia, Pa.	B	Activated Sludge

Table 7. PRIORITY POLLUTANT SAMPLING INFORMATION

Parameter	24-hour Composite	Grab Sample	Sample Container	Preservative
Non Volatile	X		1 Gallon Glass	Ice
Metals	X		1 Gallon Plastic	HNO_3
Mercury		X	1 Quart Plastic	HNO_3
Cyanide		X	1 Quart Plastic	NaOH
Phenolics		X	1 Quart Glass	H_3PO_4
Asbestos		X	1 Quart Plastic	Ice
Volatile		X	40 ml Vial	Ice

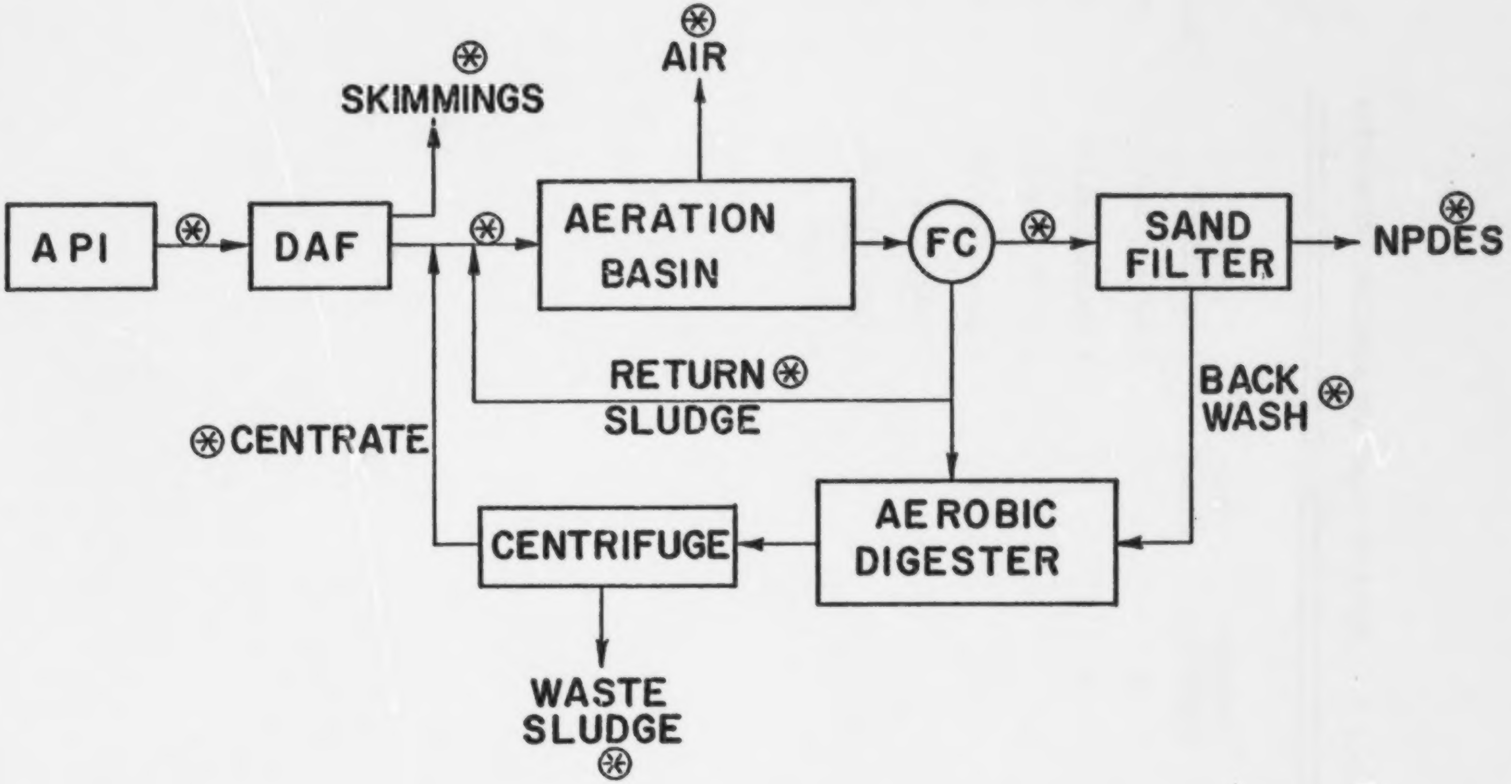
API
DAF
SKIMMINGS
AERATION BASIN
AIR
FC
SAND FILTER
NPDES
RETURN SLUDGE
BACK WASH
CENTRATE
AEROBIC DIGESTER
CENTRIFUGE
WASTE SLUDGE

Figure 2. Sampling points at Sun - Corpus Christi refinery.

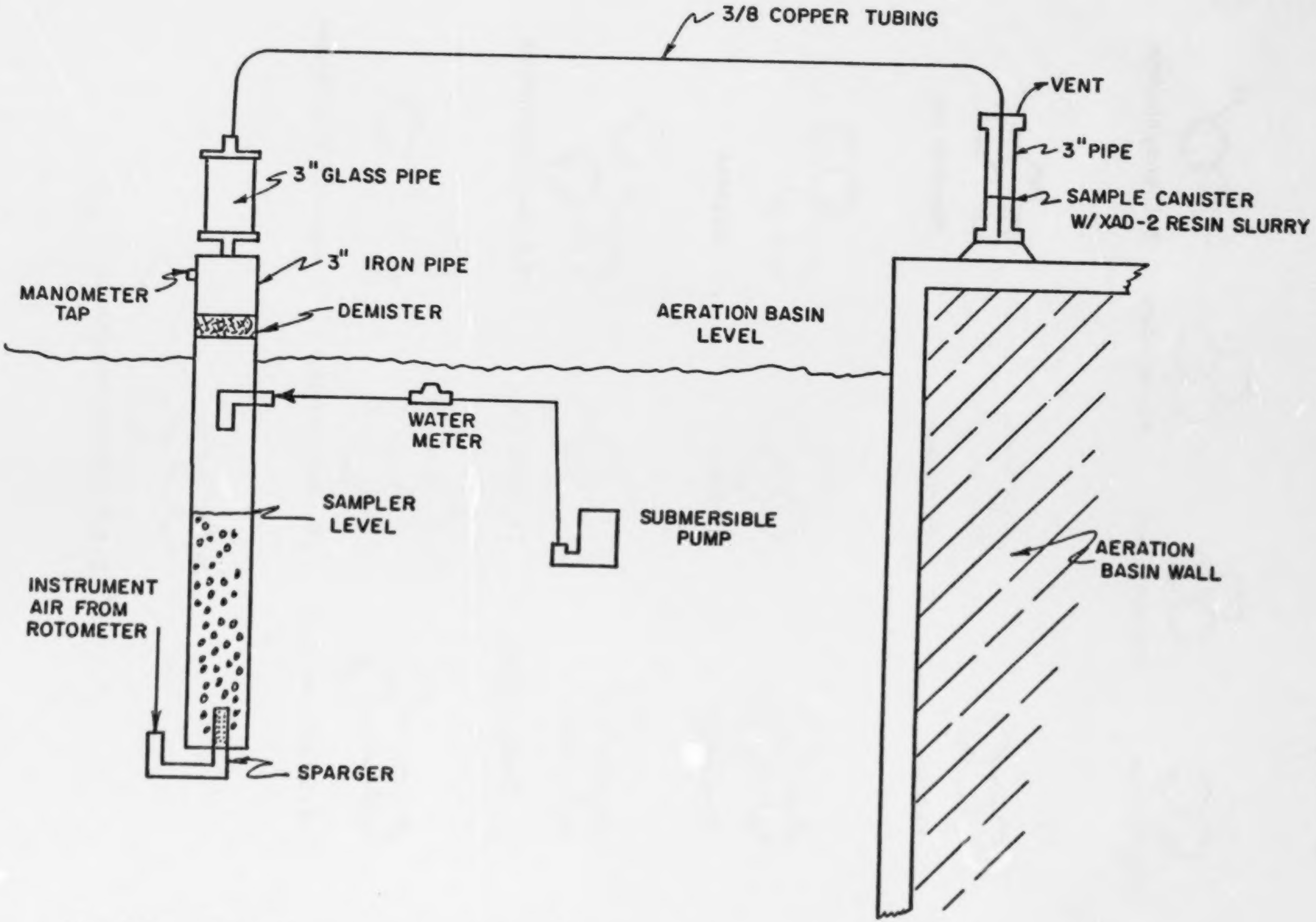
3/8 COPPER TUBING
VENT
3"PIPE
SAMPLE CANISTER W/XAD-2 RESIN SLURRY
3"GLASS PIPE
3" IRON PIPE
MANOMETER TAP
DEMISTER
AERATION BASIN LEVEL
WATER METER
SAMPLER LEVEL
SUBMERSIBLE PUMP
AERATION BASIN WALL
INSTRUMENT AIR FROM ROTOMETER
SPARGER

Figure 3. Air sampling device in the aeration basin.

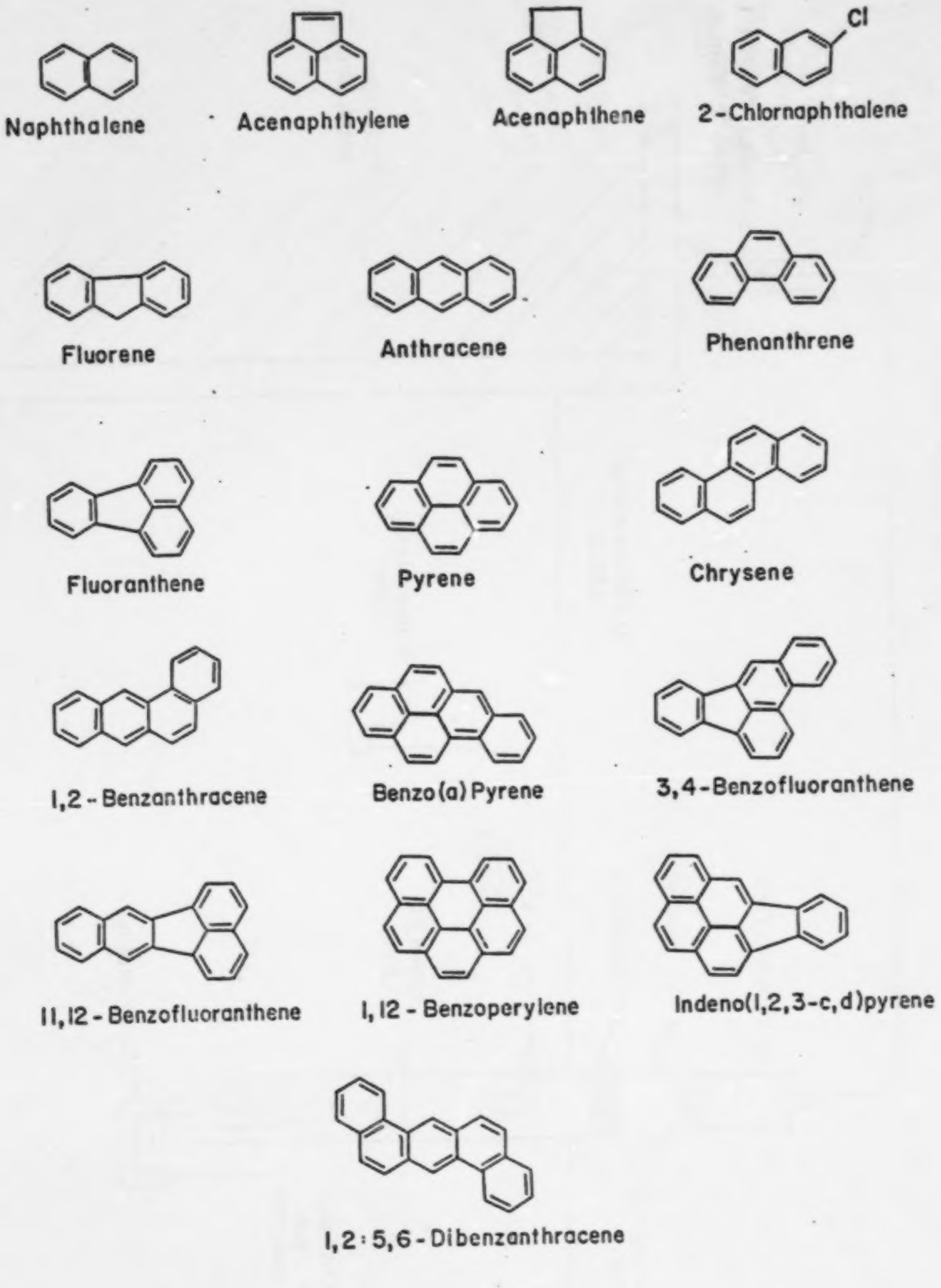
Cl
Naphthalene
Acenaphthylene
Acenaphthene
2-Chlornaphthalene
Fluorene
Anthracene
Phenanthrene
Fluoranthene
Pyrene
Chrysene
1,2-Benzanthracene
Benzo(a)Pyrene
3,4-Benzofluoranthene
11,12-Benzofluoranthene
1,12-Benzoperylene
Indeno(1,2,3-c,d)pyrene
1,2:5,6-Dibenzanthracene

Figure 4. Polynuclear aromatic hydrocarbons studied.

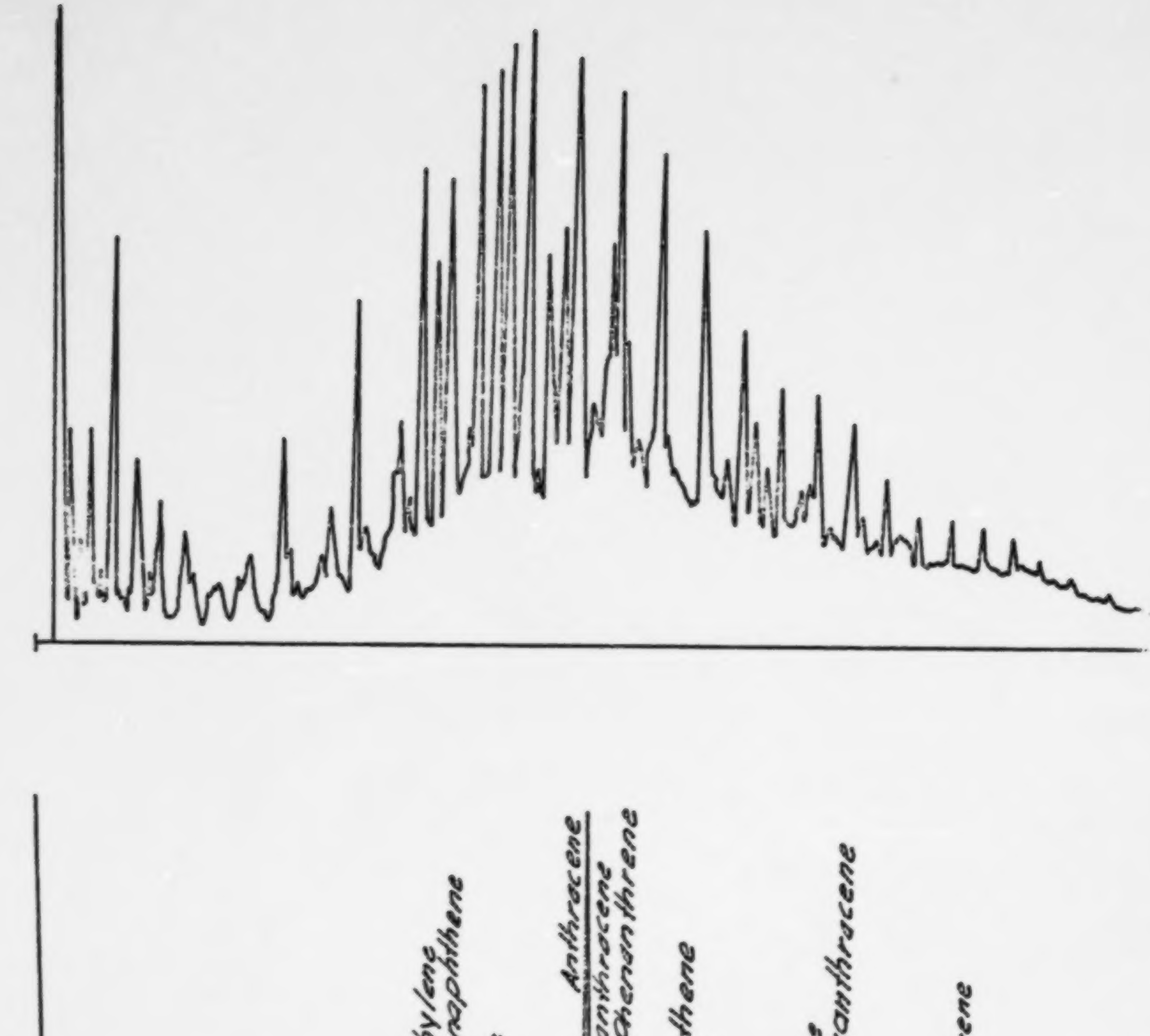

Figure 5. Comparative gas chromatograms.

WORKSHOP DISCUSSION

PART I

Fugitive Emissions Detection and Measurement

Paul R. Harrison

The session, having been held Wednesday afternoon, did not have the advantage of subsequent sessions; the sesssions and the discussions last night did touch upon this topic. The topic was, of course, detection and measurement. As far as the measurement technique is concerned, there seemed to be a general consensus (although difference in detail as you saw in some of the papers) that you have to bag fittings and, by some method or other, extract the material enclosed in the bag or enclosure, measure it, and make the proper calculations to get its leak rate. What was not discussed, is the fact that we are talking about the non-methane fraction. Although AP-42 gives you a lb/day/valve/component it doesn't necessarily talk about non-methane fractions. Methane is excluded from those leak rates (shown in paper). One thing we did not discuss is that you may have to do some analyses or, at least have analyses available. Most facilities do have an average analyses of those process streams. You could make it from that or make your own individual measurements. (Comment - Unknown - Really now we are talking non-methane and non-ethane under the definition of VOC.) I'm not completely sure of that because I have heard some people say; "Is that true in every state?" (That is true in every state.) Then, concerning the measurement methods for small leakers versus large leakers, most of the heavy leakers or what I call Class I leakers, are measured by flow meters or displacement type devices, the smaller leaker requires instrumental measurement techniques. There is an art to bagging and getting tight seals. Radian discussed - in one of its papers- not at this meeting, that bagging hot components is not a difficult task nor is it a mean trick to get done. That is some technological news and an advancement which some of us did not know how to do.

Discussion took place concerning the bubble method versus the instrumentation OVA or other methods. The bubble method was proposed. I think the statement was made that we can classify them consistently but there was no discussion about classification of bubbles, leak rates, and actual lb/day. That may be available but was not mentioned, to my knowledge, at the conference. This is as opposed to the instrumented method which, on at least two occasions, has projected average leak rates/classification. The bubble method is found to be an excellent screening method. You know you have a leak, and you can classify it and then measure it with a bag and instrumentation. But no correlation with bubble rate or size and so forth was made.

There were three instrumental techniques mentioned, one was close-in monitoring. Valves are the most prevalent leakers (using blackboard), the packing is around the valve stem. The Radian method for determining whether it's a leaker or non-leaker is (without any sub-classes at this time) to put the sensor probe right on the packing at the interface. MRI has used two methods. The method presently used is to put the probe slightly above the packing, approximately a centimeter away, and measure the sustained maximum deflection on the meter. We don't use chart recorders on this particular survey method. We classify into Class I through IV, Class I being anything over 10,000 ppm sustained maximum deflection; 1,000-10,000 - Class II; 100-1,000 - Class III; and anything less than 100 ppm would be a Class IV or an insignificant leaker. We gave some estimation in the paper, of the average leak rates of each Class. Class III is 0.01 lb/day non-methane. We didn't extract any ethane, but I don't think there was any there. Obviously the further away you go, the less the deflection you get on any particular valve. The third method was measurement 5 cm from the interface. The same thing applies to pump seals. The basic conclusion is that closer in, you do start eliminating the wind effects, turbulent effects, around the component. You get higher readings but they seem to be fairly consistent. We do have a general equivalency of the concentration at 5 cm versus 1 cm above the stem. The equivalency was approximately 3-1/2 to 4 times higher concentration for maximum sustained deflection which, as you can imagine, as the wind wafts around the valve varies greatly. If you can eliminate that problem, then you would like to do just that.

What are you really measuring? We talked about the non-methane fraction versus the total. For example, around fuel gas lines more than 90% of the emission is methane and other gases such as hydrogen. Although you get a large signal there is not much non-methane hydrocarbon. So there is a problem with the classic classification. The original classification is based on instrument deflection versus the actual non-methane fraction. When you report results in that fashion distribution does spread. The distributions are good on the high end, but because of the correction factor, there is tailing toward the lower leak rate as for the number of components versus the leak rate. The technique is getting the large leaks. You may have to fix large leakers, but they may not be largely non-methane. The obvious need is to have an explosion-proof and safe instrument. The instrumentation that we used, was the OVA. It is well accepted in these atmospheres, and of course, the soap bubble technique is also explosion-proof. By the way, there is another technique. It consists of packing a real stiff grease around the packing gland and pushing a calibrated sample tube with a squirt of a little snoop in it and watch the bubble go up. I find it difficult to get a tight seal.

We discussed the types of bags that were used, e.g., Mylar, Tedlar. If you are looking for very low levels one should use special containers. We talked about field calibration. If an instrument is used close-in some condensible, heavy hydrocarbons may be sucked in and your probe will become contaminated. Then the effective zero point will move up as these materials accumulate. For large deflections there is no problem because we are putting them in fairly gross categories. But, one has problems if you try to calibrate after using the instrumentation near condensible vapor leaks, especially for low level calibration gases. To make field calibrations, especially when you have been around high concentrations of condensibles, use at least 100-1,000 ppm calibration gases. The higher the concentration, the better your calibration will be. Don't try low level zero calibrations unless you have decontaminated the flow system within the instrument.

The other significant area of discussion was the transect, and how can you relate that to individual fittings. As far as I know you can't. It was suggested that measuring the average leak rate of these classes and multiplying by the number of fittings in the classes you may not reach the total fenceline fugitive emission rate. The reason for that is that the fenceline measurement will include spills, low volatility material that degases slowly, etc. We also concluded that you should never make a fenceline measurement in low wind speed because of the heat rising effect.

Tedlar seem to be the best for grab samples. They should be analyzed within 24 hours, especially for some of the heavier hydrocarbons. Hydrocarbons above C_5 could be obtained on activated charcoal with carbon disulfide extraction. However, you lose the C_1-C_5 portion.

We talked about in-place hydrocarbon monitors. They seem to give you some general idea of the performance of the unit, but we didn't come up with any detailed plan to relate that to individual fittings.

We discussed walk-through monitoring versus fixed monitors. The walk-through probably is more effective but even that had some problems of detection. It would give you a little better idea of the performance of the particular components close to the transect walk line than a fixed monitor. There is no substitute for individual, complete coverage. But, there are some compromises which may be desirable.

WORKSHOP DISCUSSION

PART I

FUGITIVE EMISSIONS CONTROL

Fred Storer

Generally the emphasis of the discussion was on the reduction of leaks from existing fugitive sources as opposed to what might be done with new devices to eliminate leaks. The time was spent learning what each other knew about the different sorts of leaks. With respect to valves, it was generally agreed that valves were the largest source and most productive place to emphasize fugitive controls. However, there were no real ideas offered or general agreement on what were feasible objectives. It was mentioned that a fugitive emission reduction program would lead to improvements in valve design which would ultimately reduce fugitive emissions in new sources. It was also emphasized that the results of surveys and experience with fugitive emission control programs needed to be communicated to the valve experts within the companies, to the valve manufacturers, and to the purchasing department. With respect to flanges, it was generally agreed that flanges were not a productive source for special emphasis. Relief valves were discussed and their general control techniques: inspection/maintenance programs, connecting relief valves to flares, and installation of rupture discs. Both the flare situation in existing plants and the rupture disc installation were considered in that those items may have some safety compromises, depending on the individual installation and for that reason any sort of a general across the board requirement would be very difficult. Pumps were discussed, and it was agreed that inspection would tend to reduce emissions from pumps; that the most important sources were pumps pumping high-vapor pressure materials; that some pumps or maybe even a majority of pumps that are now equipped with packed seals could be converted to mechanical seals, although that is not the general rule; and that it was less probable that an existing pump could be converted to a dual mechanical seal with a barrier fluid. Compressors were briefly discussed, and the consensus was that it was very difficult to define an action level or set what might be reasonable goals for fugitive emission control programs. Cooling towers were discussed and it was pointed out that many important leaks in cooling towers are detected, that the leaks result in operating problems with the cooling tower, problems with the algicides, chlorine residual, etc. Some people have monitoring programs on cooling towers both for the detection and for sleuthing out leaks. Also, some people have good monitors in the plumes from cooling towers to detect leaks of light hydrocarbon.

WORKSHOP DISCUSSIONS

PART I

POINT SOURCE EMISSIONS

Larry Johnson

We had a description from Radian on the point-source sampling that they are doing as part of the refinery environmental assessment. Most of the discussion here had been concerned with the valves. They are also looking as often as they can at three point sources in the plant: those are sulfur recovery units, CO boilers, and process boilers. Things have gone fairly smoothly on these. They haven't sampled as many of them as they would have liked, partly because many of these units do not have sampling ports or facilities for doing the sampling in a straightforward manner. There have been a few other minor problems which were discussed. In trying to use an instrumental method for NO and NO_x, they had some problems with getting the sample from the stack to the instrument without changes in the sample, and they have gone to a chemical method to get around that. Something either the same or very similar to Method 7 which is tricky but works if you know how to use it. We discussed some of the techniques that were being used and they seem to be using more or less standard techniques and not having too much difficulty with them.

The other topic we discussed was discussed in the session on regulations, but we had a preview of it. This was the problem with offsets and what is going to happen when it gets difficult or impossible to get an offset. A little bit of disagreement was generated in the session.

Radian is using source assessment sampling system or SASS train. The block diagram of this train was developed in the Process Measurements Branch of IERL/RTP. The actual machinery was put together by Aerotherm/Acurex This machine is a 5 cfm expanded version of the Method 5 train. In addition to being larger, it has capability on the front end for size cuts; it has a module after the filter which can be loaded with sorbent --we use XAD-2 (about 135 grams) and from there on back it looks somewhat like a Method 5 train. In the impingers instead of water we put an acid oxidant which will catch mercury and similar materials. It is an attempt, and a fairly good one, to get everything in one shot. The only thing we really don't catch this way is very, very volatile organics. Anything with a boiling point below about 100°C, goes on through to the oxidative impingers and gets all chewed up. The train seems to be, on this project, working about like it is on others. There are some mechanical sealing problems with the train. The train can be modified to make sealing better, and future models will have better seals. It takes three men to run and we usually sample for five hours with it. This is because many of the sources we look at have very low loadings. This is also why it's a big train. For a 5-hour sampling run, you end up with something on the order of an 8-hour clean-up/preparation time. So you are talking about a 12 or 13-hour day to get a run. But you get organic, inorganics and sizing.

WORKSHOP DISCUSSIONS

QUESTIONS AND ANSWERS

D. D. Rosebrook - I would like to add to what Larry said. One of the things we are trying to do is to determine the efficiency of the control technology that is now in place on point sources. In order to do this, we must measure on both sides of any control device. We have tried for over a year and finally found a place that we could get access on both sides and we made simultaneous SASS train runs. We had two SASS trains running simultaneously, so we are finally getting some control efficiency data.

L. Johnson - If anybody is interested in finding out more about the train or how it was built or what it does, you can contact me or call Bruce Harris or Bill Kuykendal and we will send you lots of information.

Jim Daily - What was the control device that he was sampling up and down stream?

A. - The devices were a scrubber and a CO boiler, both on the same stack.

L. Johnson - Let me add one thing about the SASS train. Since you are getting sizing on the front end, you have to have constant flow rate through it or the cut points will change. Thus, you don't get a true isokinetic sampling with the SASS train. It has all the controls necessary to do that, but if you utilize that feature you lose the sizing. So, you can either take the cyclones out and do true isokinetics or, if your source is even reasonably stable, you can take your velocity traverse, and set the nozzles to the right size so that you get isokinetic as long as it doesn't drift too much. So we have dubbed that as pseudo-isokinetic because as long as it doesn't shift around it is pretty good.

Jim Daily - Generally speaking, going upstream of the CO boiler, the piping configurations are such that you never find a spot that you don't have a turbulent situation. (Where you don't have too few diameters from the last bend to get true traverse and get a proper sample point.)

A. - Well, we are not too worried about that on environmental assessments because we are not trying to be as accurate, if you will, as somebody that is doing compliance testing. Also we don't normally traverse with a SASS train because it is very big. You can do it. Normally we try to find some average point and put the train in there and take the 4 or 5 hour sample without moving it.

Jim Daily - Are you recording particulates?

A. - Particulate sizing and loading, but it is not a compliance test. You would be surprised how little difference it has made. We have done a SASS validation run with three different contractors, two SASS trains and a Method 5 train. The results are very, very close; much closer than any of us thought. Now this is in a fairly well behaved source. That report is not quite available yet, but it will be soon.

Jim Daily - On the critical analysis of the organics in stacks, are you taking the same type of critical analysis of organics in the ambient air in the vicinity of the equipment at ground level?

A. - On the Radian program I don't know.

D. D. Rosebrook - No we are only taking the total hydrocarbon concentration at the inlet. We are not doing the complete breakdown.

L. Johnson - In general, on the environmental assessment programs, the fugitive emissions part of the work is sometimes implemented and sometimes not. We have it in the protocols and we have protocols for doing it. A truly 100% complete environmental assessment would include that type of thing. But, budgetary requirements and a number of other things, very often mean that you trim your program a little bit; and since that is one of the more expensive things, it is usually one of the first things that are written out.

Jim Daily - In early gas chromatographic work that was done on stack sampling from gas-fired furnaces the total organics at ground level in the vicinity of the furnace were higher than the organics in the stack. Do you have to take that into consideration?

A. - Yes. That can occur in cooling towers too. That can happen in a lot of places and isn't unusual. That can happen with particulate too. Especially if you have a baghouse or something.

Q. - A question on detection of VOC leaks. The EPA's letter to the states on revising the SIP's this year calls for controlling VOC's as needed to meet the oxygen standard. The EPA policy statement on volatile organics published in the Federal Register defines them to exclude methane and ethane. Is there any practical method from a screening standpoint in looking for leaks in refineries to detect leaks of VOC as defined by the EPA so you don't spin your wheels looking for methane and ethane limits?

A. Paul Harrison - There are two methods that occur to me. One, is knowing what your product line is or what is in your service lines. The other method involves screening instruments that can be obtained with a 36-inch GC column which is called a "methane column". You can perform a quick GC analysis on-site, at the sample point, using this particular device. We have done some of that, but it does take a long time. As you know our technique is to survey the entire facility as opposed to one or two units. It takes so long to get GC analysis that we'd rather trust the product line or service analysis than to actually conduct an individual GC on every fitting that is leaking.

K. C. Hustvedt - If you use a charcoal filter on the OVA, take the total and then put the filter on it and get your methane fraction, and take the difference between the two to get the non-methane fraction.

Q. - What about ethane?

A. - I don't have any comment.

Jim Daily - Refinery fuel gas lines are primarily methane and ethane.

A. - I think by far the best way is to just know what you are sampling.

Comment - Fine if that reflects the regulation you are working under. But if it is a soap bubble test for total organics, then you are not measuring VOC.

A. - Good point. Of course, some of the importance behind this is safety and product savings. So, on one side you have the regulatory problem and on the other side you have the economics problem.

Comment - There might be some interesting liability problems in having a record of leaks discovered that you haven't fixed.

J. Daily - There also might be litigation on the required control of all leaks if the Federal law specifically says methane and ethane are not important.

D. D. Rosebrook - I have a question for Fred Storer. Could you elaborate a little more on putting monitors in cooling tower plumes and the value of this, liability of it?

A. - Someone in the discussion group pointed out that it had been done. I don't have any knowledge of it and I don't even recall who made the suggestion. If the person is here maybe they could address that. It is a fairly simple thing to do, but I don't know how useful the information would be. I suppose that if you had a problem with reoccurring leaks of light components that would flash as soon as they would hit the atmosphere, the monitor might be useful. As a pollution control device, I don't know. I don't think that was the purpose.

Atly Jefcoat - I have always been under the impression that the operators or maintenance people in the refinery watch the cooling towers for the appearance of an oil skim then they would know when a heat exchange or something was leaking. How widespread is monitoring of cooling towers? Is this a common practice or is it not?

Fred Storer - I don't know. I don't think it is a common practice. I think watching the cooling tower and watching things like the chlorine residual and some of the other parameters in the cooling tower is a common practice and certainly watching for oil in the cooling tower basin is a common practice.

Comment - We have one plant that has been doing that and I don't know what their action level is. It may be that when they have a problem with the cooling tower, they make a GC analysis of hydrocarbons in the water to help find the source of a leak.

Comment - That problem was discussed in the Wastewater Treatment Session also. We've done it and maybe that is the appropriate place to put a monitor.

Comment - J. Daily - Better refineries do monitor, say weekly, hydrocarbons in and out through the cooling tower. You can always tell when you have an instantaneous big leak, it will blow the spray nozzles off the top of the spray head.

Atly Jefcoat - Some of these things are self-evident.

Comment - Well there are two methods. One is to measure the hydrocarbon in the water in and out. The other is to put a device in the effluent side or the air side of the top of the cooling tower and monitor that for the volatiles.

D. D. Rosebrook - Was there any discussion of flares as a point source?

A. - Larry Johnson - I mentioned it in our session and really there was no real experience in that group on flares.

WORKSHOP DISCUSSIONS

PART II

Emissions from Waste Treatment Facilities

Fred Pfeffer

The workshop dealing with Emissions from Waste Treatment Facilities divided its time between two topics. One was fugitive emissions from the treatment train, particularly the API separator. The second topic was solid wastes. We didn't cover anything else from the wastewater treatment facility.

In the realm of fugitive emissions, we started by discussing the sampling of non-methane hydrocarbons from an anaerobic pretreatment lagoon. We went from there to the factors that affect the emissions of hydrocarbons from physical treatment systems that are ahead of biological systems, such as effects of sparging with air, the variability in composition of the influent - particularly the oil content, the presence of emulsions, and the presence of floating oil.

Then we went on to the problems associated with something like an API separator. They are not easy to sample. We noted in our discussions that any attempt to do a mass balance for emissions (what goes in minus what comes out equals emissions) has not been sucessful. We disucssed how to physically sample the air emissions including a discussion of "a transectional" system of measurements. (A system attempting to account for background hydrocarbons, wind velocity and direction, elevation effects, etc.)

In the solid waste area we discussed the on going studies in solid wastes concerning leachability, characterization of the leachate and effects of the leachates. The discussion moved to the very tedious and expensive analytical problem to prove that a particular solid waste is not "hazardous". This might entail very extensive biological testing. We discussed the Ames test, the rodent acute toxicity test, bio-accumulation, effects on algae, effects on daphne and effects on fish. A very elaborate scheme may be involved here. Then chemical testing such as complete metals analysis may be required. And then into organics testing which may, from a specific organic standpoint, have to account for up to 99% of the organics that are found in that sample.

We briefly covered the implication of rule making. A problem that may arise if EPA specifies re-use of the final effluent. If this final effluent goes back to cooling towers, what happens as far as an increased organic load getting out from a cooling tower. It was a very enlightening workshop.

WORKSHOP DISCUSSIONS

PART II

Regulations

Leigh Short

The discussion was summarized very accurately by Lloyd Provost from Radian who is a statistician who said that we discussed 27 points and agreed on three of them and he wasn't too sure about the third.

The first item I think worth bringing to your attention was the distinction between the use of "frequency" in the regulations and frequency of leaks, versus the way at least it is perceived. The Draft Guideline Document as written now refers to a concentration measurement. The discussion concerned whether it would be better to have the regulation reworded or reworked saying that it will be based on frequency of leaks of valves. The discussion brought out points concerning how do you define frequency and how do you define a leak and what technique can be used for measurement. I think those are obviously three key variables. There also was a discussion of the soap test versus any instrument test. Frank Mesich discussed Radian's information to date, which shows that the distribution of leaks, particularly in valves, is spread across the whole temperature range they have sampled. There is a very significant fraction of leaking valves that you can't soap test.

The next part that came through very clearly to me, of the 27 points discussed, was that each refinery is probably going to be a different situation and different sampling case. The regulations as they end up at the state level should provide for flexibility both in how they are administered and in allowing them to be changed as the process goes on. The point was made very strongly that there is essentially no data base at this point to determine what the improvement target should be. The data coming out of Radian's work, measures leaks in the refineries as they are now maintained. There is very, very little data in that study, at this point, about what happens when you go out and try and maintain the leak, how much you can fix, what percent reduction do you get, and how long does that last.

Another point I want to bring up is that CARB, if I heard them correctly, has a staff report which is proposing that the regulations there say no operator shall operate a facility with a leaking valve or a leaking flange. His definition of a leak was no bubble. Aside from whether you agree with the regulation or not, it points up the difficulty of defining what is meant by a leak and what is meant by a frequency. The Radian data, for example, when they define leaks is at a very different cutoff in terms of concentration. EPA's document defines a leak as 10,000 ppm. The Radian leak is defined at a much lower value because they are looking at the whole statistical range and not just the high leaking range.

The other point I want to make about flexibility is that the numbers which Frank Mesich presented and which were assiduously copied down by everybody there, indicate that the frequency -- number of leaking valves -- varies by type of unit within a refinery. The regulation ultimately should reflect that variation when there is enough data to make a statistically valid statement. For example, based on Radian's definition of frequency, the percent of valves leaking ranges from about 20% up to about 50% as you change units within a refinery.

There was a large discussion about the frequency of checks. How often should you go in and sample, both looking for leaks and by sampling individual sources. The usefulness of a walk-through system was discussed in terms of whether it will tell you what you are looking for and whether the cut-off which is 100 ppm will directly lead you to the high leaker. Further, will it lead you to spurious results? A discussion occurred on the definition of a walk-through, because every refinery is different. If you have one such as the one I am familiar with, with a huge bank of air coolers, what do you learn if you walk through that, other than it is very windy.

WORKSHOP DISCUSSIONS

PART II

Equipment Considerations

Alton Williamson

We started off with a discussion of wastewater separators with HC control. It has been demonstrated but is not common. These are relatively new, but tank manufacturers will make them. We discussed in particular the inert gas separator blanket, internal floating covers, parallel plates, and CPI's. We should look at the control methods on all of these to determine whether there are other improvements that are not being used or if some others are needed.

The subject of vacuum eductors was discussed briefly. What are they? How are they used? What are some of the problems with them? No one knew of recent improvements other than the fact that in some of the old systems they are not being vented to flares and they should be and could be.

The biggest discussion concerned what we heard all week, valves. Valves are a problem. Having had two or three equipment manufacturers in the session, we did talk about a lot more than just what's new or what is going on or what is available that we are not using, some of the problems. We won't go into all that. The discussion centered around materials, particularly packing materials and forms of design. If we used more packings with automatic take-up instead of the common gate and globe valves either with a fixed or adjustable packing, emissions may be reduced. The problem arises because refineries are so top heavy with gate and globe valves because of the API standards and the fact that they are older valves and have proven themselves in the past. Non-lubricated plug valves whether they are sleeve type or ball valve or some other type of valve like that, are lower maintenance item products, however, they haven't demonstrated that they have the applicability yet. One of the strong recommendations was to tell the valve manufacturers to get us quarter-turn valves that are more reliable at higher temperatures. This led to discussions on metallic seals and other types of improvement.

We discussed the fact that the standard packing gland can be used in many different ways. One adaptation that is not used as much as it should be and could be is purging with nitrogen. Using a higher pressure than your internal pressure would force the valve to leak inward.

A limitation to the plastic packing injectable system that I had mentioned yesterday, whether you call it grease or whether it is a special sealing injection medium, is that the temperature must be less than 500°, so this would prohibit expanding this feature into higher temperature applications and maybe we need improvement there.

We talked about different new packings that have been used. It was mentioned that some of the very sensitive packings do have very good applications in packing glands, but they also have some limitations. We discussed laminous, labryinth type seals, and ribbon type seals, and how they could be applicable and where we need new improvements in this area.

We discussed a little bit about the necessity of improving fire safe valves of all kinds. Ball valves have fire safe standards to go by (16 or 18 different standards, depending on whether it is international or domestic). But, there are not many fire safe standards for other valves. Maybe we need an improvement there.

How many valve manufacturers really recommend regular maintenance. My comment was maybe only about 10%. It depends on the type of valve, the specialty and the project. When you are just buying standard valves off the shelf for what we call standard API refinery business, I doubt if there is a maintenance recommendation given except in a repair manual.

We also discussed the need to use more pressure energized metallic seals, especially in the 600-1200° range which is becoming more common. Also if we use more packings with sacrificial metals in them, that would help eliminate corrosion on parts that cause packings to leak prematurely.

We recommended cost-effectiveness studies on both single and double mechanical seals for pumps and nitrogen purges on the linear rings, I found it was common that when we require secondary seals, losses in lb/hr is reduced drastically. The cost-effectiveness seems to be there and ought to be examined in more detail.

We discussed secondary seals on open-top and floating roof tanks and felt that these are cost-effective even when retrofitted and maybe there ought to be more work done along this line.

In summary, the strongest recommendation was the need for obtaining better maintenance procedures from the valve manufacturers.

WORKSHOP DISCUSSIONS

PART II

Fugitive Emissions

James W. Daily

It was brought out that there are 264 refineries in the United States and they are owned by 156 separate and distinct oil companies. There are about 8 or 10 representatives at this session, and the decisions that are being made here are partly bracketed by what these 8 or 10 companies think. The National Petroleum Refiners Association does represent all 156 companies, so we will have to see what kind of hue and cry comes from the other 146 after the 10 that are here have heard and discussed and looked into what is coming out of this meeting. We spent most of our time on valves, we didn't discuss relief valves at all. We did talk briefly on pumps, briefly on compressors as to what kind of pumps and compressors they might be, whether they are reciprocating or centrifugal, and whether the leak rate was the same and whether the solutions were the same. Radian's study shows the leak rates aren't all that different, but the solutions, of course, are different for obvious reasons.

The question arose about what else was being studied by Radian. One of the points that was discussed at our session was the health effects of the measured emissions from these sources, and what they are contributing to the overall public health problem from hydrocarbons. The Radian study showed that the types of contaminants and pollutants that are coming from refineries are the lighter, more volatile materials, very few were highly olefinic and very few were heavy aromatics.

There were several suggestions about the appropriate method of control i.e., whether regulations should be very specific or whether they should give control limits and let the refineries determine how they would reach them. The question arose as to whether there is any actual present correlation between the lower limit hydrocarbon leakage that Radian was measuring and the lower limit soap for bubble testing.

The cost-benefit question arose. That question is very difficult to pin down because the benefit, in terms of savings, continues to rise as the value of the product increases.

The last point that was brought up was that the Clean Air Act Ammendments of 1977 are written in such a fashion and the procedures are presented in such a way, that we will reach a zero growth situation very rapidly. In other words, tradeoffs under the regulations will disappear very rapidly - any kind of tradeoffs -- with the present definitions of non-deterioration and non-attainment. That covers 80% of the nation's population area. Thus, we are headed rapidly toward a zero growth. But the saving grace is that the public recognition of- and public outcry about the situation would be so loud and hopefully in sufficient time that the law would be changed, the regulations would be changed.